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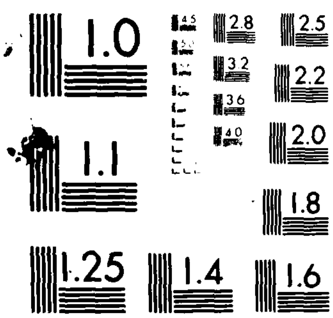

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Mr. Terry Hannah
Defense Systems Management College (DSMC)
Building 209, Room 208
Fort Belvoir, Virginia 22060

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(Continued next page)

20. ABSTRACT (Continue on reverse side if necessary and identify by block number)

This study analyzed the problems of increasing lead times that have been experienced in the acquisition of major weapon systems during the past decade. Items that had significantly increasing lead time were identified and classified. In cases where sufficient lead time data was available, trend analysis was conducted. Causes of increasing lead times were identified and assessed. Based on the above effort, alternative courses of action were developed, which have potential for alleviating increasing lead times.

(Continued next page)

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20. Abstract (continued)

Alternatives were categorized and evaluated for feasibility of implementation by Program Managers, DoD, Congress and other government departments, and industry.

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1. INTRODUCTION

1.1 Background. During the past decade Program Managers (PMs) for major weapon systems acquisition, as well as all the echelons in the Department of Defense (DoD) involved in the acquisition process, have become increasingly concerned over the dramatic schedule slippages and the overall lengthening of time required to accomplish the acquisition process and field major weapon systems as a result of increasing lead times*. This concern has even been described as alarming, as lead times of certain items were observed to skyrocket in recent years. Many of these unanticipated schedule extensions have resulted in notable problems, not only for PMs, but throughout DoD in the planning, programming, and budgeting process. Further, these schedule implications are many times directly translatable in funding implications requiring Congressional action. These same concerns regarding increasing lead times were expressed by the private sector as well. DoD has taken procedural action to minimize some of the problems attributed to longer lead times; however, these actions in most cases have addressed symptoms rather than causes of the problems.

1.2 Discussion. The 1970s contained a variety of social, economic, and national security influences that impacted to varying degrees on the acquisition of major weapon systems. As in other decades of the past, the overall impact of the interrelationships of the influences combined to make the 1970s unique. Some of the significant events that occurred are listed below and presented in Figure 1.1.

- The Vietnam War wound down and a truce agreement was signed in 1973.
- Business cycles occurred with three recessions of varying degrees occurring in 1969-1971, 1974-1975, and 1979-1980 time frames.

* Lead Time - The time elapsed between the placement of an order or request for action and the initiation or completion of that action.

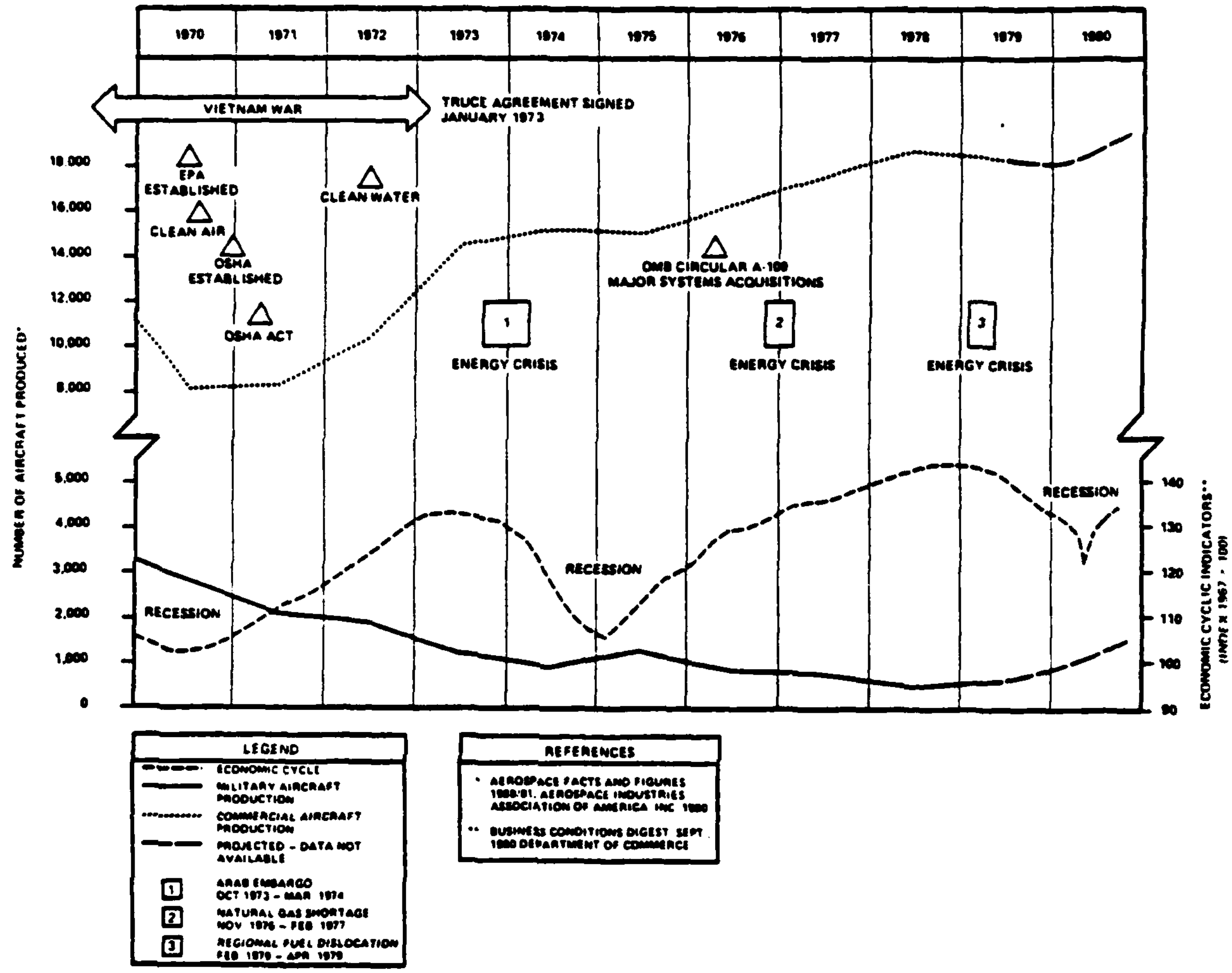


Figure 1.1. The Environment of the '70s.

- Commercial aircraft production commenced increasing significantly in the early 1970s as military aircraft requirements and both commercial and military shipbuilding continued to decline.

- Microelectronics and miniturization of electronic components sparked a new commercial electronic era in the early 1970s, in minicomputers, word processors, home entertainment centers, electronic appliances, and toys.

- Federal environmental and occupational safety and health regulations were enacted in the early 1970s that subsequently resulted in the closing down of literally hundreds of small yet significant foundry operations.

- Three energy crises occurred in the latter part of the 1970s that resulted in the curtailment of raw material refinement, production, and transportation delays due to the energy shortages.

- Inflation continued to increase into the double digits throughout the 1970s.

As these and other socioeconomic factors (which will be discussed in Section 3 of this report) interacted, many lead times for major weapon systems acquisition, particularly those in aerospace, lengthened. Some of the more dramatic changes for aerospace items are illustrated in Table 1.1. Acknowledging that the private sector has varying degrees of specialization, as will be discussed in Section 3, distinct differences were noted in lead times for aerospace items as compared to armored vehicles and shipbuilding items. See Table 1.2 for some example comparisons.

1.3 Study Objectives. Recognizing the need to evaluate the causes of increasing lead times such as those cited in Tables 1.1 and 1.2, the Defense Systems Management College (DSMC) proposed that such a study be conducted and the results be developed into a final technical report that would prove beneficial to Program Managers by providing them with (1) an understanding of the underlying causes, including their interrelationships, (2) identification of possible alternative courses of actions that might alleviate some of the lead time problems, and (3) recommendations for the most feasible or beneficial courses of actions to be taken.

1.4 Organization of Report. This final technical report has been structured to facilitate its use by Program Managers. Accordingly, instead of presenting a discussion of the study methodology used in this research effort in the first sections of the report, the discussion is presented in Appendix F. An Executive Summary is presented in Section 2 summarizing the study requirements and the study results that are considered both informative and potentially benefi 'al for Pr gram Managers, and those recommended for DoD to

TABLE 1.1. AEROSPACE INCREASING LEAD TIME

ITEM	FROM		TO	
	YEAR	WEEKS	YEAR	WEEKS
Forgings, Titanium, Large*	1972	25	1980	150
Castings, Aluminum	1972	10	1980	52
Landing Gear*	1973	60	1980	120
Integrated Circuits (I/Cs)	1972	12	1980	59
Engines, Aircraft	1977	82	1980	162
Airframes	1977	95	1980	198

* Most significant increases occurred between 1977 and 1980.

TABLE 1.2. LEAD TIME COMPARISONS

ITEM	1980 LEAD TIMES	
	AEROSPACE	SHIPBUILDING
Bearings, Large	68 weeks	56 weeks
Castings, Aluminum	53 weeks	11 weeks
Forgings, Large, Aluminum/Alloy	102 weeks	38 weeks
Integrated Circuits (I/Cs)	60 weeks	40 weeks

consider. Section 3 provides the main discussion of long lead time items and their causes, and cites potential alternatives that could help alleviate long lead time problems. Section 4 discusses the alternatives identified in Section 3 and categorizes them as to their implementation feasibility at the PM level or within the purview of DoD. Research results and recommendations are summarized in Section 5. Appendices A, B, C, and D present compendia of information on critical raw materials, bearings, castings and forgings, and integrated circuits (I/Cs), which should provide PMs with a better understanding of some of the underlying factors affecting these most critical long lead time items. The results of the long lead time item trend analysis are presented graphically in Appendix E. Appendix F contains a discussion on this study's objectives and the research methodology. This is followed by a reference listing and a bibliography.

2. EXECUTIVE SUMMARY

This Executive Summary provides an overview of the study of increasing lead times in major weapon systems acquisition.

2.1 Research Effort. The research effort entailed a comprehensive literature search and review, as well as many interviews with personnel involved with various aspects of long lead items in major weapon systems acquisition within DoD, government, and industry. From these sources items were identified that had significant increasing lead times during the 1970s. Items were classified as follows:

- Raw Materials
- Processed Materials
- Components
- Subsystems
- Systems
- Services

Items that were identified as having the most significant increases in lead times were bearings, castings, forgings, and integrated circuits, and these were subjected to more in-depth analyses.

Next, the research effort established the causes associated with each classification of long lead items. Causes were then analyzed as to the contributing influences and also as to the interrelationships between causes. Major causes were grouped by category of influence, such as: government factors, industry factors, or market factors. (For listings of specific causes identified, see Tables 3-2, 3-5, 3-8, 3-11, 3-13, and 3-16.) Some of the more significant causes of increasing lead times were:

- Government
  - The lack of stability in major weapon systems acquisition resulting from annual funding, insufficient front-end planning and communications.

- Industry

  - The lack of investment in and stockpiling of critical raw materials and other long lead items.

  - The lack of investment in applied technology, equipment, and facilities.

  - The shortage of engineers, technicians, and other skilled craftsmen.

- Market

  - The significant competition of commercial demands in certain business sectors such as aerospace and electronics.

Items with lead time data were analyzed for trends and distinct differences were noted between aerospace, armored vehicles, and shipbuilding items. Based on analyses of the causes, in each classification of increasing lead time items, alternative courses of action were proposed for alleviating the long lead time problems in each classification (see Tables 3-3, 3-6, 3-9, 3-12, 3-14, and 3-17).

The proposed alternatives were consolidated and evaluated for feasibility of implementation by Program Managers, DoD, Congress and other government departments, and industry. All alternatives were considered feasible to various degrees. A brief summary of the alternatives is provided below:

Program Manager Cognizance

- Propose use of multiyear procurements
- Improve front-end planning, scheduling, and budgeting
- Improve communications with Users and contractors
- Propose use of advance procurement funding
- Increase their understanding of the business environment within which their acquisition occurs
- Establish early design stability
- Implement and monitor Defense Priorities System (DPS) rating

- Establish a "time" tracking project such as PERT, CPM
- Include contract provisions and/or incentives for increasing capitalization, productivity, and quality control
- Combine purchases of end items, spares, and repair parts
- Conduct trade-off studies
  - Mil-Spec vs commercial items
  - Use of substitute materials
- Define realistic R&D objectives
- Establish realistic schedules for R&D
- Implement and monitor Defense Materials System (DMS) rating

<u>DoD Cognizance</u>

- Increase use of multiyear procurements
- Increase use of advance procurement funding
- Establish a viable system to track long lead items and to disseminate data
- Consider alternatives to state-of-the-art development, such as pre-planned product improvements
- Promote adequate up-front planning to improve program stability
- Promote use of small firms and independent inventors in defense R&D efforts either directly or through subcontracts with prime contractors
- Promote combining of end-item, spares, and material requirements to increase order quantities
- Promote use of incentive type contracts to improve quality and timeliness of end products
- Define R&D priorities for more emphasis on critical long lead items
- Evaluate MANTECH program emphasis
  - increase MANTECH program funding
  - assess aerospace and shipbuilding foundry and milling compatibility
- Promote the application and monitoring of the DPS and DMS

- Request enforcement of DPS and DMS by the Department of Commerce

- Request Department of Commerce to include all acquisition critical raw and processed materials in DMS

- Review contractor requirements for data and documentation for possible reductions

- Incentivize industry to conduct defense related R&D

Congress or Other Government Departments Cognizance

- Authorize increased use of multiyear procurements

- Authorize increased use and duration of advance procurement funding

- Authorize improvement of depreciation policies

- Authorize decreased corporate taxes

- Decrease OSHA/EPA regulations impact on the defense industrial base

- Authorize increased mining of public lands

- Reestablish revolving fund and promote use of Title III of the Defense Production Act of 1950

- Establish government subsidized training programs for engineers, technicians, programmers, analysts, and other critical skills

- Authorize increased MANTECH program funding

- Establish an effective energy allocation system

- Promote reduction of paperwork required of subcontractors

- Implement enforcement of DPS and DMS

- Incentivize industry to conduct defense related R&D

- Encourage use of small firms and independent inventors in defense R&D efforts

Industry Cognizance

- Invest in applied technology, equipment, and facilities

- Invest in and stockpile critical raw materials and other long lead items

- Promote in-house and on-the-job training programs for critical labor skills

- Establish program for improving product quality during production

- Improve compliance with DPS and DMS ratings

- Improve communications with suppliers of raw materials, components. Increase marketplace knowledge and research

- Advise customer of known material problems early to allow for advance planning, budgeting, and scheduling

- Explore possible use of substitute materials and wider use of off-the-shelf items

- Increase subcontractors and suppliers incentives

- Consider subcontracting portions of defense R&D effort with small firms and independent inventors

- Increase emphasis on defense R&D, innovation

The following proposed courses of action would be the most beneficial by reducing the impacts of the more significant causes of long lead time problems:

- Increase the use of multiyear procurements to reduce the fluctuations being experienced in many single year funded programs.

- Improve front-end planning and stabilize the design as much as possible and as early as possible to reduce the impact of changes.

- Improve communications between Users, PMs, and contractors in order to provide a better understanding of the details and overall aspects of a program and thus insure better planning, budgeting, and scheduling.

- Increase business incentives such as decreased corporate taxes to encourage investment in and stockpiling of critical raw materials and other long lead items. Also increase use and duration of advance procurement funding.

- Promote investment in applied technology, equipment, and facilities through increased business incentives, including improvements of depreciation policies, reduced taxes, and increased MANTECH program funding.

- Establish in-house and on-the-job training in industry, and establish government training programs for engineers, technicians, and other critical skills.

- Develop a better understanding of the business environment in which the acquisition takes place in order to improve planning, budgeting, and scheduling.

2.3 Need for Further Study. Included in the alternatives cited above are a number of ideas that need further study and consideration.

- Develop a viable long lead item tracking system (see Section 4.3.2), including:

  - identify items to be tracked by standard nomenclature,

  - develop procedures for collecting, analyzing, retaining, and dissemination data,

  - develop long lead item forecasting techniques incorporating economic indices, socioeconomic events, etc.

- Evaluate the potential for intersector, i.e. aerospace, armored vehicles, and shipbuilding, industrial support flexibility (see Section 4.3.5).

- Evaluate data and documentation requirements imposed on contractors to determine what can be simplified, reduced, or eliminated (see Section 4.3.10). Paperwork involved with government procurements is the primary reason that small firms are reluctant to do business with government.

3. LONG LEAD TIME ITEMS

3.1 Introduction. In planning for major weapon systems acquisition, Program Managers (PMs) must realize they are not confined to a small business world microcosm consisting only of their own organization and those of their prime and subcontractors. Although PMs are normally well aware of the internal DoD influences on their programs, they may not always appreciate the fact that their programs are influenced directly or indirectly by outside socioeconomic pressures, many of which can affect programs in an adverse manner. During the research interviews of this study, many respondents suggested that one of the ways PMs could improve their performance would be to become acquainted with the "marketplace"; in other words, to become cognizant of the business environment within which their acquisitions occur. This understanding can provide a basis for improved program planning. The next section, Section 3.2, will provide an overview of the more significant influences on major weapon systems acquisition during the 1970s. Then, Section 3.3 will discuss specific items that have been experiencing increasing lead times, causes identified as contributing to these increases, and possible alternatives for alleviating them.

3.2 The Past Decade. As an illustration of the "marketplace" in the 1970s, Figure 3.1 provides a look at some of the influential factors that affected the acquisition of military aircraft, as well as other major weapon systems that will be discussed in Section 3.2.1. In addition, Figure 3.1 highlights internal DoD factors such as the increased emphasis and guidance provided by DoD on major weapon systems acquisition, which have influenced programs. Some of the concerns and ramifications regarding certain aspects of existing DoD guidance will be discussed in Section 3.2.2.

3.2.1 The economic climate. By looking at the "marketplace" or socioeconomic environment of the '70s, one can identify a number of causes for increasing lead times experienced during this period (see Figure 3.1).

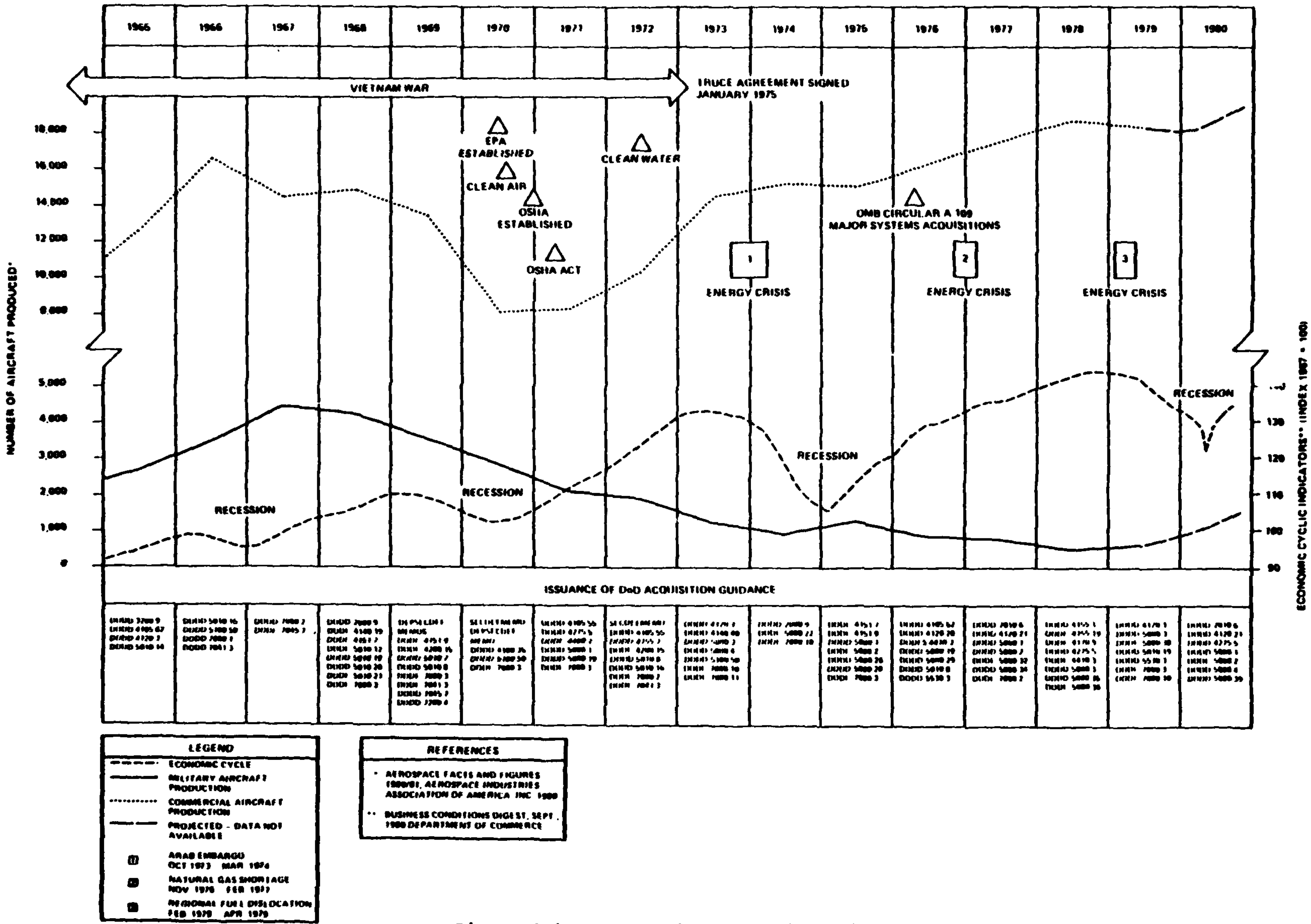


Figure 3.1. The Environment of the 1970s.

- DoD procurements became less of an influence in the business world as the Vietnam War effort declined and finally terminated. At the same time the commercial consumer business continued to gain momentum as evidenced by the growth in the Gross National Product (GNP) (see Figures 3.2 and 3.3). Some small businesses left the defense industrial base citing as their reasons the appeal of the more lucrative and growing commercial market, as well as the frustrations with government paperwork, start and stop productions, short production runs, and the additional effort required to comply with Military Specifications (MIL-SPECs). As a result, fewer subcontractors and suppliers existed to support prime defense contractors, thus affecting lead times.

- As military aircraft procurements continued at a low ebb during the '70s, commercial aircraft production increased significantly over the decade. In 1971, for example, military aircraft constituted 21.4 percent of the total production of 10,390 aircraft. By 1973, this percentage had declined to 8.5. Then by 1979, a total of 19,196 aircraft were produced, of which only 3.8 percent were military aircraft (Ref. 1). The significant increase in overall aircraft production created a high demand for aerospace materials and parts, which caused delays in deliveries due to supply shortages.

- The enactment of environmental and occupational safety and health regulations in the early 1970s required industries to invest in pollution abatement and improved working conditions. Most firms and corporations were either mildly affected or had sufficient funds with which to comply with the regulations. Unfortunately, in the foundry industry several hundred foundries discontinued operations as compliance with the regulations was financially prohibitive. As a result, order backlogs and lead times for casting increased dramatically to an extent that aerospace castings having lead times of 10 to 20 weeks in 1972 are currently in the 50 to 80 week range. It must be acknowledged that a certain portion of these increasing lead times is attributable to the availability of casting materials at the foundry levels.

- Energy intensive industries felt the effects of three energy crises in the late '70s. Refineries and mills converting raw material into processed material were adversely effected dur to energy curtailments, as was the transportation industry. Although the impacts of the energy crises on increasing lead times have not been specifically identified, it will be noted that after the first and most significant energy crisis in 1973 - 1974, a recession occurred and lead times fluctuated in an adverse manner. The effects of inflation and interest rates, coupled with small tax incentives during the 1970s, discouraged many firms from investing in new capital

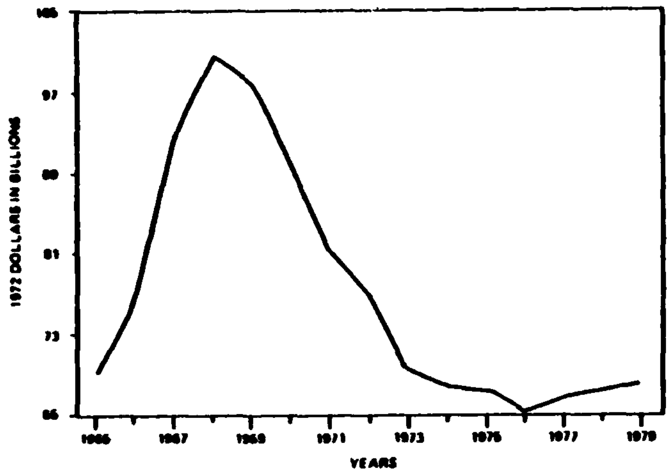


Figure 3.2. Real Defense Budget.

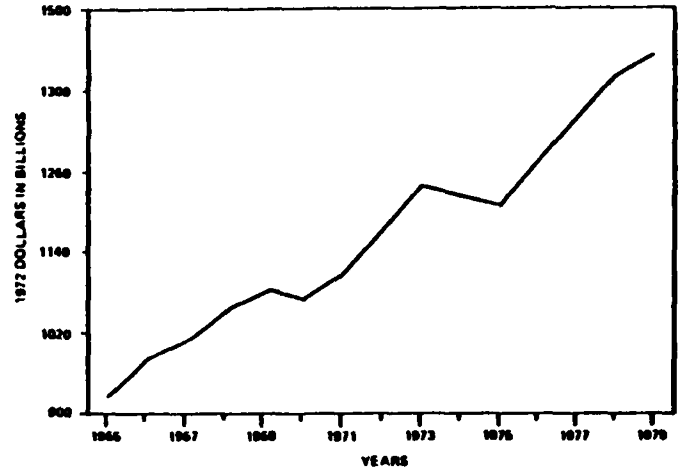


Figure 3.3. Real GNP.

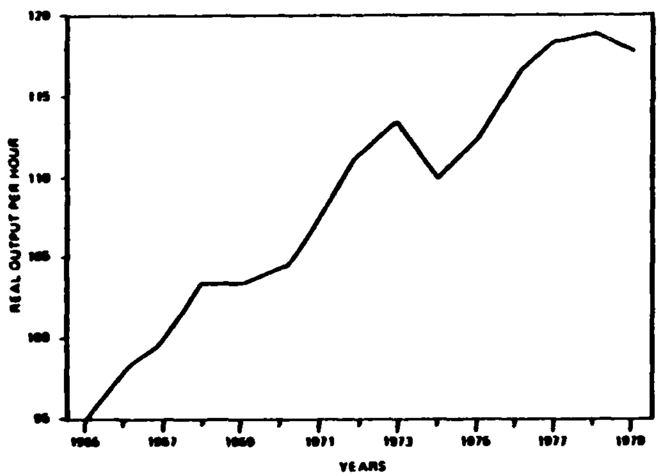


Figure 3.4. Productivity (1967 = 100).

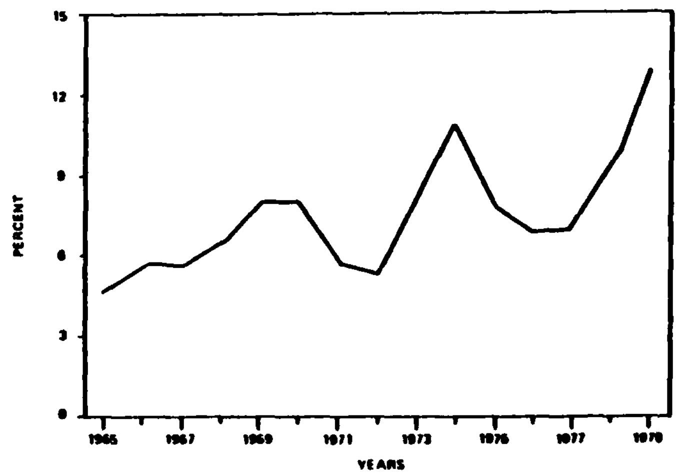


Figure 3.5. Prime Rate.

equipment and plant property. This lack of investment has resulted in declining productivity, which in turn has increased lead times for manufactured products. The decline in productivity growth rate has been highly evident since 1977 (see Figure 3.3).

- The increasing shortages of skilled craftsmen during the 1970s, particularly in the field of tool and die makers, have caused backlogs and shortages in the tooling and machining industries by lengthening set-up and tooling operations. In 1980, the National Tooling and Machining Association (NTMA) estimated that vacancies existed in industry for approxiately sixty thousand skilled journeymen and this figure would continue to increase.

An examination and analysis of cyclical economic indicators over the past 15 years can also provide insight into the business environment to which DoD and Program Managers have been subjected.

Figure 3.4 presents a productivity index that, while generally increasing, has exhibited a lower rate of growth in recent years. Declining productivity has been cited many times as a contributor to increased lead times. The fluctuations of the prime interest rate (Figure 3.5) has many ramifications, including inventory level (Figure 3.6) and effects on the cost of capital. High interest rates have a dual effect on increasing lead times by contributing to industry reluctance to carry large inventories and by curtailing expansion plans. Even though nonresidential investment (Figure 3.7) has been increasing, the figures as a percentage of Gross National Product (GNP) have not increased. Moreover, these figures do not even mean that investment has been for expansion, as vast expenditures are needed just for replacement of worn out or obsolete capital equipment. The huge sums of investment needed for compliance with OSHA/EPA regulations further restricts the amount available for expansion. In spite of high unemployment rates (Figure 3.8), critical manpower shortages have been a problem cited as contributing to long lead times. The capacity utilization trend (Figure 3.9) bears a logical relationship to the lead times trends presented in Appendix E. Lack of sufficient capacity has been cited as one of the most significant causes of long lead times and an increase in capacity utilization normally translates to increased lead times and production bottlenecks.

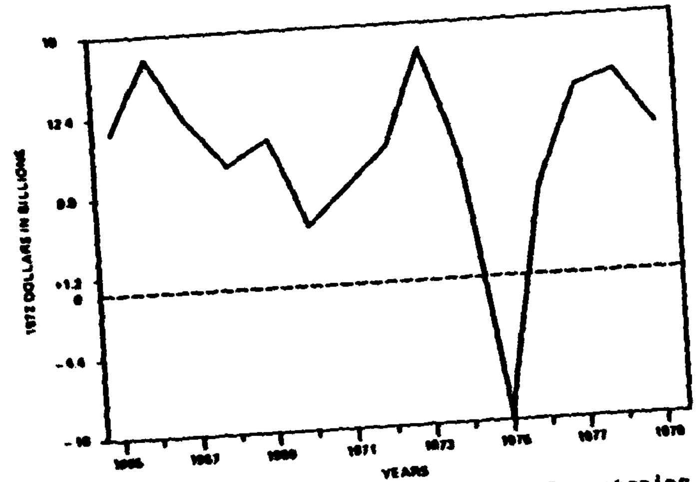


Figure 3.6. Change in Business Inventories.

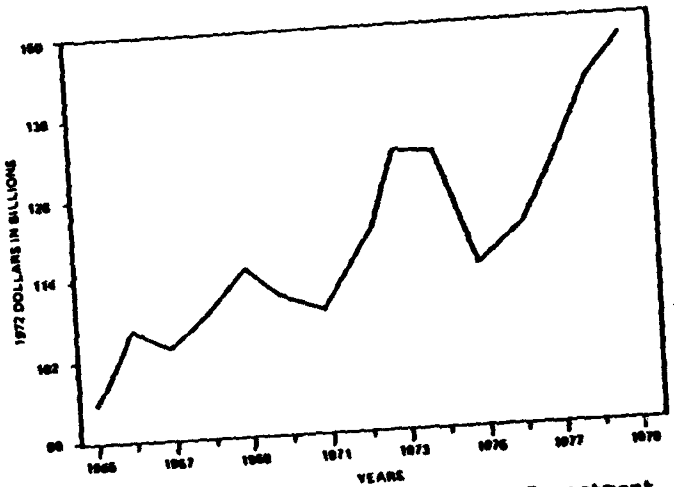


Figure 3.7. Real Nonresidential Investment.

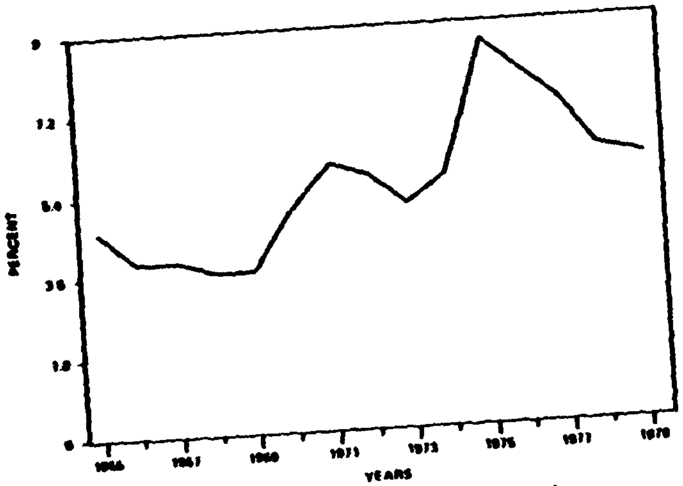


Figure 3.8. % Unemployment.

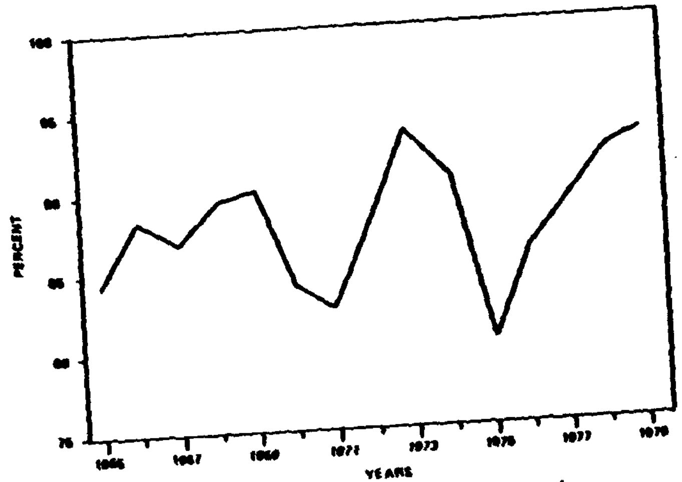


Figure 3.9. Capacity Utilization.

One must realize that regardless of the attention and understanding a PM has of the socioeconomic environment of his program, there will always be risks and uncertainties such as labor strikes, energy shortages, Congressional political considerations, and the President's budget.

3.2.2 The DoD acquisition environment of the 1970s. DoD policy guidance for major weapon systems acquisition has been cited as both a benefit and one of the indirect causes for increasing lead times in the 1970s. Figure 3.1 illustrates the number of major DoD weapon systems acquisition guidance issued, revised, and updated throughout the past decade and in prior years. Appendix F provides titles and dates of publication for each guidance document identified. In addition, numerous change notices have also been issued. DoD Instruction 5000.2, "Major System Acquisition Procedure," of 19 March 1980 lists over one hundred twenty (120) DoD directives and instructions applicable to major weapon systems acquisition. In addition, there is the contractual guidance provided by the Defense Acquisition Regulations (DAR).

Overall, DoD policy and procedures guidance for acquisitions of major weapon systems proved generally beneficial, although their effectiveness has been defused through the multiplicity of issuance and overlapping areas of guidance. Frustrations have been encountered in the private sector due to a need to understand and comply with DoD guidance, which entails paperwork and data requirements not usually encountered in a commercial business environment.

Within DoD, the review cycle established by the Defense Systems Acquisition Review Council (DSARC) in 1969, as well as a layering of service reviews, has caused delays in many programs. The issuance of the Office of Management and Budget (OMB) Circular A-109 in 1976 added potential delays by requiring a formal statement of need document and thus another review cycle. The uncertainties associated with the reviews are felt by both the PMs and the contractors involved.

Program Managers (PMs) should insure that they and their staffs are cognizant of all effective DoD and appropriate service weapon systems acquisition policies and procedures. This understanding should facilitate the development and execution of an effective acquisition strategy in a timely manner and thus

preclude unanticipated delays in the acquisition process such as insuring that adequate preparation is made for Service Systems Acquisition Review Councils (SSARCs) and DSARCs, long lead time items are identified and advance procurement action is taken, Government Furnished Equipment (GFE) is provided in a timely manner, etc. In addition, with a good comprehension of the applicable acquisition policies and procedures, PMs can interact more smoothly with contractors, and also assist contractors in understanding and complying with DoD acquisition policies and procedures.

3.3 Increasing Long Lead Time Items. Thousands of specific items have been identified as examples of long lead time items affecting the acquisition of major weapon systems. The research effort of this study has identified and classified those items considered to be the most significant drivers of increasing lead times. These items and their related causes will be discussed in this section. In addition, possible alternatives for alleviating the lead time problems will also be presented.

Lead time has been defined as the time elapsed between the placement of an order or request for action and the initiation or completion of that action. For procurement items, lead times are usually based on a sampling of vendors or contractors. It should be noted that this report does not address the surge or mobilization potential of the defense industrial base; however, the research effort confirms the concerns expressed recently by Mr. Dale W. Church as Deputy Under Secretary of Defense for Acquisition Policy (Ref. 2), General John R. Guthrie (Ref. 3), General Alton D. Slay (Ref. 4), and Admiral Alfred Whittle, before the Defense Industrial Base Panel of the Committee on Armed Services (Ref. 5).

3.3.1 Raw materials. The lead time implications associated with raw material availability are of paramount importance to the overall issue of increasing lead time for defense weapon systems. The longer a fabricator must wait to obtain the necessary materials, the longer lead time he must quote to his buyers. The recent problem with titanium metal serves as an appropriate example: in 1980, aircraft forgers were faced with delays of up to 50 weeks and longer in obtaining titanium, thereby increasing lead times for titanium products to record highs. Table 3.1 lists critical raw materials that have

TABLE 3.1. RAW MATERIALS

MATERIAL	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Aluminum	X	X	X	X	X	X	X	X	X	X
Asbestos	X	X	X	X			X	X		X
Beryllium	X			X						
Cadmium	X			X						
Chromium	X		X	X	X		X	X		X
Cobalt	X		X	X	X		X	X		X
Columbium	X		X	X			X	X		
Copper	X	X	X	X	X	X	X	X		X
Magnesium	X		X	X			X	X		X
Manganese	X		X	X						
Mica	X	X	X	X	X	X	X	X	X	X
Molybdenum	X		X	X			X	X		
Nickel	X	X	X	X	X	X	X	X	X	X
Platinum	X	X		X	X		X	X		
Tantalum	X	X	X	X			X	X		
Titanium	X		X	X			X	X		
Tungsten	X		X	X			X	X		

been identified as causing increasing lead times in major weapon systems acquisition and are cross-referenced to major system applications. A brief overview of each of the critical raw materials is presented in Appendix A, and lead time trends can be found in Appendix E.

3.3.1.1 Causes of increasing lead times. Many factors impact the availability and lead times of raw materials, including import dependence and domestic mining activity. A complete list of major causes of increasing lead times for raw materials can be found in Table 3.2. Alternatives for reducing long lead times are presented in Table 3.3 and are discussed in Section 3.3.1.2.

3.3.1.1.1 Import dependence. The U.S. is dependent on imports for many raw materials used in the production of military hardware, as well as in commercial applications; in many cases the dependence is over 90% of domestic consumption. Many studies have been done and much has been written recently regarding this country's vulnerability to foreign sources of supply for critical materials. In most of the reports, however, the lead times of the minerals and metals are only incidental to the more important aspects of supply disruptions or total cutoffs due to political exigencies. In a peacetime and free world market scenario, lead time becomes more a function of aggregate supply. For instance, recent shortages of molybdenum caused problems, although it is a metal on which the U.S. is self-sufficient. In other words, import dependence in and of itself is not directly correlated to high lead times. What is important is a relatively stable supply, but unfortunately many critical materials have origins in unstable areas such as Southern Africa. In recent years, United Nations trade sanctions against Rhodesia (now Zimbabwe), as well as insurgent fighting in Zaire, curtailed supplies of two vital metals, chromium and cobalt, which in turn impacted products using these metals. Such instability has also curtailed the frequency of mining ventures in foreign countries by American concerns as lack of protection by foreign governments and the possibilty of expropriation become realities. More information about supply and import dependence of various raw materials that have been identified as critical to major weapon systems acquisition can be found in Appendix A.

3.3.1.1.2 Domestic Mining Activity. The U.S. mining industry has been beset by many problems that tended to perpetuate our dependence on foreign sources of supply. Ineffectual public policy designed to strengthen domestic mining activity conflicts with laws that regulate the industry, with the net result being a lack of a coherent long-range plan. On one hand, the Mining and Minerals Policy Act of 1970 calls for the government to encourage private enterprise in the development of economically sound and stable domestic mining, minerals, and metals industries. (Ref. 6). On the other hand are public safety laws promulgated over the past decade including the Clean Air Act, Mining Safety and Health Act, Federal Water Pollution Control Act, and the Resource Recovery and Conservation Act (Ref. 6). These acts, singularly and collectively, have adversely affected mining concerns with respect to the distortion of free market forces that might otherwise encourage exploration and extraction of minerals. Additionally, the obstacles to mining public lands cause the time required for obtaining a mineral lease and mining plan to exceed three years. This time lag further restricts the industry's responsiveness to market conditions.

The mining industry has also had long term capital formation problems. Over the past 7 years, the industry has committed up to 25% of its capital outlays to comply with Federal air, water, and safety standards, while expenditures to modernize were deferred (Ref. 7). The great need now for increasing efficiency and expansion is being thwarted by the high cost or unavailability of funds. The combined effects of increasing costs due to the purchase and operation of nonproductive pollution control equipment, restrictions on access to public lands, and continuing uncertainty in the area of new and amended regulations make mining investments very risky propositions.

3.3.1.2 Alternatives. Alternatives for alleviating long lead times for raw materials and the problems associated with them are presented in Table 3.3. The Defense Production Act (1950) provides authority that enables the Federal government to underwrite expansion of domestic production of critical materials. Under Title III, the government can help establish or support existing mining companies by guaranteed sales, loans, and favorable tax treatment.

TABLE 3.2. CRITICAL RAW MATERIALS - CAUSES OF INCREASING LEAD TIMES

MARKET FACTORS

- Demand higher than supply
  - shortages
  - allocations
- Instability of foreign sources of supply
  - political turmoil
  - economic considerations
- Lack of viable substitutes
- Long supply routes

INDUSTRY FACTORS

- Limited production capacity
  - power (energy) constraints
  - land use restrictions
- Inadequate investment spending
  - little expansion, aging plants
  - high risk due to uncertainties of regulatory requirements
  - much capital spending tied to pollution control equipment
- Industry reluctance to stockpile due to exposure to unfunded financial risk
  - high interest rates make investment inventory unattractive
  - unfavorable tax treatment
- Increasing lack of American mining ventures in foreign countries
  - political instability
  - fear of nationalization

GOVERNMENT FACTORS

- Obstacles to the exploration and mining of potentially mineral-rich federal lands result in excessive dependence on foreign sources of supply
  - onerous legislation regulating pollution, worker safety, and conservation with high cost to comply
  - limited access to public lands due to strong environmental lobby
  - three year time lag to procure a mineral lease and mining plan from the government
- Lack of a coherent and effectual non-fuels mineral policy

TABLE 3.3. *CRITICAL RAW MATERIALS - ALTERNATIVES FOR REDUCING LONG LEAD TIMES*

PROGRAM MANAGER COGNIZANCE ● Investigate possibilities of advance funding for long lead time raw materials ● Evaluate competing designs with an eye towards availability of required raw materials DOD COGNIZANCE ● Increase emphasis on materials R&D to develop substitutes for critical materials ● Changes in advance procurement regulations to allow for funding of critical raw materials GOVERNMENT COGNIZANCE ● Use of Title III of the Defense Production Act to subsidize purchases of raw materials ● Reduce obstacles to the mining of public lands ● Lessen regulation of domestic mining industry ● Reduce taxes on private holdings of raw materials - provide incentives for buffer stocks of raw materials by adjustments in valuation of inventories INDUSTRY COGNIZANCE ● Prime contractor funding of advance raw materials buys by subcontractors ● Increase inventories of raw materials to cut down wait time

Reducing the obstacles to the mining of Federal lands would encourage more domestic exploration and possibly reduce our dependence on foreign sources of supply. The extent of America's mineral resources can only be estimated, and current statistics point out the fact that only one third of one percent of U.S. land is used for mining. The potential exists, but over 80 regulations administered by 20 Federal agencies have restricted and stifled most exploitation attempts (Ref. 5). There has been at least one move in the right direction, as Congress recently voted to delete some 40,000 acres of potentially cobalt-rich land from a wilderness set-aside in Idaho.

Changes in advance procurement regulations to allow funding of raw material buys could have the effect of reducing lead times by ensuring timely supply when high-demand or exotic materials are required. Further discussion as to the feasibility of the listed alternatives is presented in Section 4.

3.3.2 Processed Materials. Processed materials are the intermediate step between a refined raw material and a finished component. Metal processors are responsible for turning out a wide variety of formations such as sheets, pipes, rods, and foil made of many pure metals and alloys. In addition, special processes such as heat treatment and plating may be performed to conform to end users specifications. For example, a forger may require alloyed sheets or plates to bend into shapes required in aircraft production, and a bearing manufacturer might need rods to cut and grind ball bearings. Delays in metal fabrication can cause a component producer to stretch out the lead time he must quote to manufacture a given end item. Table 3.4 lists processed materials that have been identified as contributing to the increasing lead times in major weapon systems acquisition. The materials are also cross referenced to specific military applications in the same table. Lead time trends for selected processed materials in aerospace and shipbuilding applications can be found in Appendix E.

3.3.2.1 Causes of increasing lead times. Table 3.5 lists the major causes of increasing lead time for processed material as identified from literature research and personal interviews. As noted, one factor impacting the lead time for processed materials has been the supply/availability of raw

TABLE 3.4. PROCESSED MATERIAL

ITEM	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Bars										
- Aluminum	X	X	X	X	X	X	X	X	X	X
- Magnesium	X		X	X			X	X		X
- Nickel-base Alloy	X	X	X	X	X	X	X	X	X	X
- Stainless Steel	X	X	X	X	X	X	X	X	X	X
- Steel	X	X	X	X	X	X	X	X	X	X
- Titanium	X		X	X			X	X		X
Extrusions (Light)										
- Aluminum	X	X	X	X	X	X	X	X	X	X
- Steel	X	X	X	X	X	X	X	X	X	X
- Titanium	X		X	X			X	X		
Extrusions (Heavy)										
- Aluminum	X	X	X	X	X	X	X	X	X	X
- Steel	X	X	X	X	X	X	X	X	X	X
- Titanium	X		X	X			X	X		
Extrusions (not specified)										
- Magnesium	X		X	X			X	X		X
Foil										
- Gold-alloy		X		X						
Piping										
- Nickel Alloy							X	X		
- Steel Carbon							X	X		
Plates										
- Aluminum	X	X	X	X	X	X	X	X	X	X
- Magnesium	X		X	X			X	X		X
- Stainless Steel	X	X	X	X	X	X	X	X	X	X
- Steel	X	X	X	X	X	X	X	X	X	X
- Titanium	X		X	X	X		X	X		X

TABLE 3.4. PROCESSED MATERIAL (continued)

ITEM	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Rods										
- Aluminum	X	X	X	X	X	X	X	X	X	X
- Stainless Steel	X	X	X	X	X	X	X	X	X	X
- Steel	X	X	X	X	X	X	X	X	X	X
- Titanium	X		X	X	X		X	X		X
Sheets										
- Aluminum	X	X	X	X	X	X	X	X	X	X
- Cobalt-based alloy	X	X	X	X	X	X	X	X	X	X
- Magnesium	X		X	X			X	X		X
- Nickel-based alloy	X	X	X	X	X	X	X	X	X	X
- Stainless Steel	X	X	X	X	X	X	X	X	X	X
- Steel	X	X	X	X	X	X	X	X	X	X
- Titanium	X		X	X	X		X	X		X
Tubing										
- Aluminum	X	X	X	X	X	X	X	X	X	X
- Nickel Alloy							X	X		
- Stainless Steel	X	X	X	X	X	X	X	X	X	X
- Steel	X	X	X	X	X	X	X	X	X	X
- Titanium	X		X	X			X	X		

material inputs. A summary of the problems and causes associated with raw material long lead times is presented in Section 3.3.1. Other factors such as stringent government specifications for particular alloys also negatively impact lead time by limiting the number of qualified or willing processors. When special processing is required, the result is longer lead times, especially in a case where the raw material is in short supply. For example, specifications that called for a specially heat treated titanium product caused lead time for a helicopter component to increase on top of the already long lead time for regular titanium. In other cases, mainly in shipbuilding, military specifications were cited as being outdated, requiring use of one material when development of the latest synthetic materials were believed to result in better products (Ref. 8). Also discouraging contractors from participating in defense acquisition have been limited production runs and small batch requirements inherent in military procurement. These small runs do not provide enough incentive to a contractor to modify equipment or purchase additional test equipment. The situation for the acquisition of major weapon systems is even more crucial in industries where commercial demand precludes sufficient capacity to allow for surge demands of military requirements. Being a relatively small customer places the government at a disadvantage with respect to financial leverage and bargaining position.

Capital investment shortfalls at this level of industry are common to all sectors, and can be partially explained by unfavorable depreciation and tax policies and the high cost of obtaining funds. Other capacity constraints involve a lack of skilled craftsmen and a shortage of contractors willing to do specialty treatments. Low inventories carried by processors mean that most products are made to order with a resultant longer lead time.

3.3.2.2 Alternatives for reducing long lead times. A list of major alternatives for reducing lead times for processed materials is presented in Table 3.6. As noted, some alternatives require specifying particular materials during the design stage, a time when future material problems may not be envisioned. Continually working with industry throughout design and development might allow a consensus to be reached on design modifications using substitutes that will have the impact of reducing lead times. The Defense Materials System (part of the Defense Production Act of 1950) provides for the

TABLE 3.5. PROCESSED MATERIAL - CAUSES OF INCREASING LEAD TIMES

MARKET

- Limited demand for exotic materials, specialized treatment facilities as required by government

- High demand for processed materials commonly used in commercial applications

- Shortages of raw materials, including:
  - titanium
  - cobalt
  - columbium
  - tantalum

INDUSTRY

- Lack of processing capacity

- Limited qualified suppliers that are able or willing to conform to Military Specifications
  - special processing and testing
  - short production runs

- Low inventories, materials made to order
  - high carrying costs
  - uncertainty of demand

- Need to wait for outside contractors to do a special treatment job

- Lack of investment in capital equipment
  - nonproductive investment in compliance with OSHA/EPA regulations
  - high cost of capital

- Growing shortages of skilled craftsmen
  - tool and die makers

GOVERNMENT

- Military specifications
  - rigid specifications
  - special testing

- Requirements for special alloys, special melting processing

- Unattractive, small batch order quantities

- Lack of market clout
  - overall military demand roughly 1% of total

TABLE 3.6. PROCESSED MATERIALS - ALTERNATIVES FOR REDUCING LONG LEAD TIMES

PROGRAM MANAGER COGNIZANCE

- Examine rationale for stringent specifications, special alloys
- Explore possible use of substitute materials

DOD COGNIZANCE

- Consider use of Defense Materials Systems to provide adequate/timely delivery of raw materials
  - extend to include titanium, cobalt, and other special alloys
- Combining requirements to increase order quantities

GOVERNMENT COGNIZANCE

- Encourage expansion in industrial base
  - more favorable depreciation and tax laws
- Introduce stability in procurement policies

INDUSTRY COGNIZANCE

- Consider advance raw material buys/stockpiling
- Explore possible use of substitute materials

availability of basic materials through mandatory material set-asides. This allocation mechanism, however, currently applies only to nickel, steel, aluminum, and copper. Further discussion regarding feasibility of the listed alternatives is presented in Section 4.

3.3.3 Components. In many instances the timely availability of critical components has become the driving force behind increasing lead times in defense acquisition. Production of military hardware is vitally dependent on the supply of many components, and to the extent that these items have excessively long lead times, the whole system is delayed. Current problems in the areas of castings, forgings, bearings, and electronic components quite clearly illustrate this problem. A recent analysis of data collected on Air Force weapon systems demonstrated this effect of critical components on acquisition lead times for aircraft and missiles (Ref. 9). Table 3.7 lists components that have been identified as causing increasing lead times of weapons systems acquisition and are cross-referenced to major system applications. Separate assessments of lead time problems for bearings, castings and forgings, and integrated circuits are presented in Appendices B, C, and D, respectively. Lead time trends for selected components can be found in Appendix E.

3.3.3.1 Causes of increasing lead times. Many of the causes associated with increasing lead times for critical components have been the result of limited production capacity being strained by a surge in demand. Ways of doing business and requirements that are peculiar to DoD also account for many problems. A complete list of major causes of increasing lead times for components can be found in Table 3.8. Alternatives for reducing long lead times are presented in Table 3.9 and are discussed in Section 3.3.3.2. Causes of long lead times due to shortages of raw and processed materials inputs are discussed in the preceding two sections (3.3.1 and 3.3.2).

Lack of components has been a problem that has plagued aircraft defense contractors in varying degrees over the past decade. During 1973-1974 the lead time problem, particularly for electronic components, was indicative of the increasing lead times that would be experienced in the late 1970s. A special report by Aviation Week and Space Technology, dated 1 April 1974,

TABLE 3.7. COMPONENTS

COMPONENTS	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Accelerometers	X		X			X				
Avionic Chassis	X		X							
Bearings										
- Large	X		X	X			X	X		
- Non-Commercial	X		X	X			X	X		
- Non-Standard	X		X	X			X	X		
Batteries		X		X						
Batteries, Missiles				X						
Bolts										
- Stainless Steel	X		X	X						
- Steel Alloy	X		X	X						
- Titanium	X		X	X						
Cable (electrical)	X	X	X	X			X	X	X	
Capacitors	X	X	X	X	X	X	X	X	X	X
Castings										
- Aluminum	X	X	X	X	X	X	X	X	X	X
- Cobalt Based Alloy	X		X	X	X		X	X		X
- Nickel Based Alloy	X		X	X	X		X	X		X
- Steel	X		X	X	X		X	X		X
- Titanium	X		X	X	X		X	X		X
Circuit Board (printed)		X			X				X	X
Circuit Breakers	X		X	X						

TABLE 3.7. COMPONENTS (continued)

COMPONENTS	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Condenser, Auxiliary							X			
Condenser (Steam Booster)							X	X		
Conduit Covers	X		X	X						
Connectors, Electrical	X		X	X			X	X		
Control Systems (Automated, Boiler)							X			
Davit, Boat, Power-Operated							X			
Diodes	X	X	X	X		X			X	
Elevator Machinery							X			
Fasteners										
- Hy Tuff Alloy	X		X	X						
- Non-titanium	X		X	X						
- Nut-Self Locking	X		X	X						
- Titanium			X	X						
Flight Control Actuator	X									
Forgings										
- Small										
. Aluminum	X	X	X	X	X	X				
. Steel	X		X	X	X		X	X		X
. Titanium	X		X	X						

TABLE 3.7. COMPONENTS (continued)

COMPONENTS	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Forgings (cont'd)										
- Large										
. Aluminum	X	X	X	X	X					
. Stainless Steel	X		X	X			X	X		X
. Steel	X		X	X	X		X	X		X
. Titanium	X		X	X						
Generator, Electric (Diesel Engine Driven)								X		
Generator, Electric (Gas Turbine Driven)							X			
Generator, Electric (Steam Turbine Driven)							X			
Generator, Oxygen-Nitrogen								X		
Gun Carriages					X					
Gyroscopes	X	X	X	X	X	X	X	X	X	X
Hydraulic Components	X									
Integrated Circuits	X	X	X	X	X	X	X	X	X	X
Microcircuits	X	X	X	X	X	X	X	X	X	X
Nixie Tubes	X	X				X	X	X	X	
Optics		X				X		X	X	X
Pumps, Centrifugal/ Rotary							X	X		

TABLE 3.7. COMPONENTS (continued)

COMPONENTS	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Recoil Mechanisms					X					
Relays, Electrical	X	X	X	X	X	X	X	X	X	X
Resistors, Electrical	X	X	X	X		X			X	
Rod Ends	X		X	X		X				
Semiconductors	X	X	X	X	X	X	X	X	X	X
Sensors	X	X	X	X	X	X	X	X	X	X
Shafting, Propeller							X	X		
Speed Brake Actuator	X									
Stabilizer, Horizontal, Aircraft	X									
Struts, Shaft							X			
Switchboards	X	X				X	X	X	X	
Switches, Electrical	X	X	X	X		X	X	X	X	
Transformers, Electrical	X	X	X	X	X	X	X	X	X	X
Transistors, Electrical	X	X	X	X	X	X	X	X	X	X
Tube, Traveling Wave	X	X	X	X		X				
Valve (Reactor Coolant System)							X	X		

TABLE 3.7. COMPONENTS (continued)

COMPONENTS	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Vidicon (electron/ photo tube)		X				X				
Washers	X		X	X						
Wire, Electrical	X	X	X	X			X	X	X	

TABLE 3.8. COMPONENTS - CAUSES OF INCREASING LEAD TIMES

MARKET

- High demand for components from commercial sectors or competing DoD programs
- Shortages of raw material and processed material inputs
- Sole source of supply

INDUSTRY

- Limited production capacity
  - machine capacity
  - lack of skilled labor
- Limited qualified suppliers
- Unwillingness to do defense work
  - profit considerations
  - paperwork requirements
  - tighter tolerances
  - one-of-a-kind items
  - engineering changes
  - short production runs
  - not off-the-shelf items
- Reluctance to expand to meet temporary demand surges
- Low inventories due to high carrying costs, risk of obsolescence
- High barriers to entry for new firms
  - specialized knowledge, expertise
  - OSHA/EPA compliance costs
  - capitalization costs

GOVERNMENT

- Military Specifications
  - tight tolerances
  - high reliability
  - increased testing requirements
- Pushing the state-of-the-art
- Engineering changes
- Small, uneconomical order quantities
- Disincentives to do government business
  - profit policy
  - government paperwork and documentation requirements including cost/pricing data
- Overall regulatory burden on private idustry
  - OSHA/EPA regulations

TABLE 3.9. COMPONENTS - ALTERNATIVES FOR REDUCING LEAD TIMES

PROGRAM MANAGER COGNIZANCE

- Combine purchases of end items, spares, and repair parts to increase order quantities in flow down to vendors
- Ensure compliance with Defense Priorities System rated orders
- Study alternatives for relief of strict requirements and specifications
- Consider wider use of commercial specifications and off-the-shelf components
- Control engineering changes
- Include prime contract provisions and/or incentives for increased capitalization, productivity, and quality control of supplies

DOD COGNIZANCE

- Ensure that Defense Priorities System (DPS) rated orders flow down to second and third tier component manufacturers and suppliers of processed materials
- Improve stability in production rates
  - reduce multiyear contracting restrictions
- Improve productivity of component manufacturers through increased use of Manufacturing Technology (MANTECH)
- Support advance funding for critical materials needed for timely production of components

GOVERNMENT COGNIZANCE

- Reduce disincentives to performing government contracts
  - allow competitive profit
  - protect subcontractors from government paperwork systems
- Create employment training programs for those skills that are in short supply
- Reduce obstacles that hinder industrial base expansion
  - reexamine OSHA/EPA regulations
  - improvement of taxation and depreciation policies

TABLE 3.9. COMPONENTS - ALTERNATIVES FOR REDUCING LEAD TIMES (continued)

INDUSTRY COGNIZANCE

- Stockpile critical raw materials
- Improve quality control in production runs
- Consider wider use of off-the-shelf commercial components
- Increase knowledge of market conditions to allow for better planning

detailed the effects of increased lead times on the aerospace industry, and probably could have been republished in 1980 without much loss of relevance (Ref. 10). Firms in industries with high commercial demands have become reluctant to engage in work as defense contractors/subcontractors that require more exacting specifications and tolerances to meet military needs. Military buying patterns traditionally have been tough on component suppliers by virtue of small uneconomical order quantities, non-commercial specifications, and documentation burdens including cost/pricing data. Additional drawbacks to defense contracts include lower profitability as compared with commercial work, and short production runs of specialized, one-of-a-kind items. The result of these disincentives has been a decreased defense vendor supply base with increased lead times for critical components. In fact, for many items, the government has been confronted by a sole source situation -- a condition that does not lend itself to successful negotiation to decrease lead times. Even industries or firms with heavy dependence on defense business are unwilling to increase their capacity in times of high demand due to the vicissitudes of military procurement.

Also, increasing lead time can be the amount of time needed to physically produce an item to Military Specifications. As systems have become more complex and sophisticated, components are required to function with greater

efficiency and reliability. To meet this need, new military specifications are developed that specify tighter tolerances. This in turn has caused many parts to be reworked or rejected as a result of quality control, and has also resulted in the need for longer and more extensive testing. Compounding the problem have been delays caused by engineering changes, which in some cases, through sheer volume, have caused additional schedule delays in both development and production.

Attempts to increase capacity to improve responsiveness are often frustrated by a lack of skilled labor and high cost of capital equipment. The manpower shortage has been particularly acute with respect to foundry personnel, tool and die makers, and electronics design engineers. Low inventories as a result of high carrying costs and risk of obsolescence also have negatively impacted long lead times.

Expansion of existing firms and entry of new firms are constrained by high equipment costs in capital intensive industries. The difficulty of entry is exacerbated by the combination of high inflation rates, inadequate depreciation schedules, unfavorable tax laws, and the high cost of capital. Other factors constraining new entrants are OSHA/EPA compliance costs and the high level of technical expertise required to adequately compete in the industry.

3.3.3.2 Alternatives for reducing lead times. Most alternatives for reducing lead times for critical components in defense weapon system acquisition are focused on improving government awareness and responsiveness to market conditions and commercial business practices. Consequently, any actions to make military orders more attractive to suppliers might tend to reduce lead times. A complete list of alternatives developed from personal interviews and data analysis is presented in Table 3.9.

The Defense Priorities System (DPS) (from the Defense Production Act of 1950) is a rating system administered by the Department of Commerce that assigns priority to ensure timely completion of defense orders. However, in practice there are doubts as to the program's effectiveness, especially compliance at the subcontractor and third tier levels. Potential lead time problems should be assessed by the Program Manager early in the development

cycle of a weapon system, with consideration paid to relative benefits of tighter tolerances and specifications. Federal legislation affecting the strength of the industrial base, including taxation laws and public safety regulations, should be reexamined in light of current economic circumstances. Section 4 provides a discussion regarding the feasibility of proposed alternatives presented in this section.

3.3.4 Subsystems. Subsystems are complete assemblies such as engines, landing gear, or embedded computers used in the production of military weapon systems. These products are either produced by the prime contractor or supplied by outside sources such as subcontractors, and by the government as Government Furnished Equipment (GFE). Lead times for subsystems directly effect the total lead time for acquisition of a system. Table 3.10 lists subsystems that have been identified as causing increasing lead times of weapon systems acquisition and are cross-referenced to major system applications. Lead time trends for selected subsystems in aerospace and shipbuilding applications can be found in Appendix E.

3.3.4.1 Causes of increasing lead times. Major causes of increasing lead times for subsystems are presented in Table 3.11. Alternatives for reducing long lead times of subsystems are presented in Table 3.12 and are discussed in Section 3.3.4.2. It must be noted that a principal driver associated with increased lead times for subsystems has been the availability and lead time of components used in the manufacture of the subsystem. From research and interviews, it has been ascertained that the long lead times for subsystems have been mainly the result of cumulative effects at lower tier manufacturers and suppliers. The preceding section (3.3.3) describes the lead time problems in that context. Causes impinging more directly on subsystems include limited production facilities and special requirements of military items. Capacity shortfalls requiring a waiting period to get on machines have been the result of high commercial demand coupled with limited expansion in many industries. Drawbacks to investing in new capital equipment are general economic conditions and policies that include outdated depreciation regulations, unfavorable taxation implications, and the high cost of funds. Also, shortages of skilled personnel (particularly engineers) would make expansion

TABLE 3.10. SUBSYSTEMS

SUBSYSTEMS	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Airframe	X									
Ammunition Handling	X		X		X					
Anti-Skid System	X									
Attitude, Velocity & Control System, Satellite (GPS NavStar)				X						
Bleed Air Duct System	X									
Blower, Forced Draft							X			
Boiler, Auxiliary Steam							X			
Boiler, Main							X			
Capstan, Power Driven							X			
Control Stick Boost Pitch Compensator	X									
Crane, Electro Hydraulic							X			
Crane, Electronic							X			
Distilling, Plant							X	X		
Embedded Computer	X	X		X	X	X	X	X	X	X
Engine, Diesel							X			
Environmental Controls	X									
Engine	X		X	X						

TABLE 3.10. SUBSYSTEMS (continued)

SUBSYSTEMS	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Gun, Aircraft	X									
Hoist, Bi-Rail Trolley (Electric/Missile Handling)							X			
Landing Gear, Aircraft	X									
Launcher Frame				X	X					
Navigation System, Satellite (GPS NavStar)				X						
Reduction Gear							X	X		
Rotor Head			X							
Secondary Power	X									
Turbine							X	X		
Turret										X

futile for many companies. Compounding the investment problem for defense contractors have been the uncertainty of military procurement, as well as nonallowability of certain costs as specified by procurement regulations. In addition, lower profitability of defense business as compared to commercial, added to the onerous reporting and paperwork requirements, give little incentive to increasing responsiveness to the military sector. Firms are also reluctant to order components in advance or to stockpile components due to uncertainty of future business as a result of single-year funding. This uncertainty causes companies to be denied planning visibility while being forced to risk their own capital for long lead time items that would be needed only if anticipated procurements materialize.

Demands imposed by Military Specifications also have been cited as a contributor to increased lead times of defense weapon subsystems. The inherent complexity of such items is manifested by the extensive reliability testing and debugging that is required. Any changes in design parameters via Engineering Change Proposals (ECPs) can aggravate a long lead time by necessitating different manufacturing processes and by sending repercussions down through the supply line of component vendors. The time period needed to evaluate proposals and competing designs and to negotiate a contract also add to the lead time of a subsystem.

3.3.4.2 Alternatives for reducing long lead times. A list of major alternatives for reducing lead times for subsystems is presented in Table 3.12. Again, as with causes, alternatives that relate principally to reducing the lead time for components used in the manufacture of subsystems can be found in Section 3.3.3. At the subsystem level, actions that are taken to improve design and funding stability would promote better long range planning of financial and productive resources. Other actions to encourage more participation by industry in defense procurement would also have the effect of reducing lead times. Section 4 provides a discussion of alternate actions including the feasibility of proposed alternatives presented in this section.

3.3.5 Systems. The delivery of a system can be the culmination of hundreds of thousands of individual actions and decisions accomplished by the PM's office, other cognizant Service and DoD offices, the prime contractor,

TABLE 3.11. SUBSYSTEMS - CAUSES OF INCREASING LEAD TIME

MARKET

- High demand from commercial sector competing for limited production facilities
- Shortages, long lead times, for components
  - inability to obtain commitments from key suppliers due to vicissitudes of defense business

INDUSTRY

- Shortage of skilled design engineers
- Unwillingness to order/stockpile components in advance
  - uncertainty of military procurement
- Disincentives to seeking defense contracts
  - lower profitability
  - detailed paperwork requirements
  - nonallowability of certain costs such as interest
- Disincentives to invest in new capital equipment
  - depreciation and tax policies
  - high cost of capital
- Design complexity

GOVERNMENT

- High realibility required
- Extensive-testing requirements
- Changes in design parameters
  - engineering change proposals
- Design complexity
- Lack of adequate advance funding
- Lack of multiyear stability
- Long period to evaluate proposals and negotiate contracts

TABLE 3.12. SUBSYSTEMS - ALTERNATIVES FOR REDUCING LONG LEAD TIMES

PROGRAM MANAGER COGNIZANCE

- Encourage design stability
- Investigate advance procurement funding possibilities
- Propose use of multiyear procurements
- Consider use of off-the-shelf subsystems
- Ensure compliance with Defense Priorities System rated orders
- Evaluate specification needs, including substitutions for components and materials identified as long lead time items
- Consider combined procurements of end items, spares, and repair parts
- Control engineering change proposals
- Consider use of contract incentives for increased capitalization, productivity, and quality assurance

DOD COGNIZANCE

- Reduce paperwork requirements
- Provide economic incentives to improve industry responsiveness
- Encourage program stability
- Support advance funding for critical subsystems

GOVERNMENT COGNIZANCE

- More stringent enforcement of Defense Priorities System
- Employment programs to assist in acquiring and training personnel
- Multiyear funding changes

INDUSTRY COGNIZANCE

- Work with Program Manager to allow for proper planning, scheduling and budgeting
- Work with subcontractors to keep apprised of impending problems
- Increase emphasis on R&D, innovation

subcontractors, and numerous suppliers. Many of the actions and decisions can affect the lead times of the acquisition either beneficially or adversely as discussed in the previous sections.

The timing of the actions and decisions can be critical to the completion of an acquisition; for example, the later that design and engineering changes are proposed and made in an acquisition schedule, the greater the slippage impact on the schedule, or the later a decision is made to provide funds for advance procurement of long lead time items, the less possible impact it will have on improving the acquisition schedule.

3.3.5.1 Causes of increasing lead times. The causes of increasing lead times for a system's acquisition are a collection of the individual causes identified for raw materials through subsystems, plus the causes listed in Table 3.13 for the overall system. Alternatives for reducing long lead times of systems are presented in Table 3.14 and are discussed in Section 3.3.5.2. The total impact of the causes depends on the degree and extent of the influences.

3.3.5.1.1 Market factors. The increasing competition from the commercial sector, together with the decrease in defense procurements, has resulted in firms and corporations departing the defense industrial base for the more lucrative long term business in the commercial sector. In addition, the increased competition means competition for raw material, processed material, components and subsystems, plant capacity, and even manpower, all of which can cause increases in lead times. This is particularly evident in the aerospace industry.

The shipbuilding industry has experienced increasing lead times over the past decade; however, they have not been as significant as those experienced in aerospace. Of growing concern is the continued aging of plant equipment and facilities in the shipbuilding industry caused by the austere shipbuilding efforts in the 1970s.

The increasing number of large multi-market conglomerates has affected lead times as each sector of a corporation competes for capital for investment

in future business. Since many corporations do not consider defense business profitable, plant equipment and facilities required for defense business are not being upgraded.

3.3.5.1.2 Industrial factors. As mentioned above, the increasing age of applied technology in plant equipment and facilities has had a demonstrated impact on increasing lead times in the past decade. The influences of inflation, interest rates, taxes, and cash flow problems have also contributed to the decline in capital investment and to and the declining productivity being experienced in American industries. Also affecting productivity has been the increasing shortage of all categories of engineers, technicians, and skilled labor, especially computer programmers and analysts, electrical and optical technicians, precision machinists, and tool and die makers. As a result of the shortage of skilled craftsmen and aging equipment, and the need for tighter tolerances, product quality control has become increasingly difficult, causing more rejections and rework.

The Defense Priorities System (DPS) requires contractors and suppliers to accept and give preferential treatment to DX or DO rated orders and contracts. In interviews, comments regarding the application and use of the DPS were cited a number of times as having an impact on the problems of increasing lead times. Interviewees stated that some contractors, particularly subcontractors and suppliers, had commented that a rated order, especially the DO rating, was not given any priority over unrated orders; also, in many instances, subcontractors and suppliers were not advised of the rated orders recieved by the prime contractor or subcontractors (Ref. 11).

3.3.5.1.3 Government factors. The continuing lack of stability in DoD's Five Year Defense Plan (FYDP) combined with the associated defense procurement budget decline and fluctuations has had its repercussions felt in the acquisition of major weapon systems. Private industry has become wary of the changes and adjustments that occur each year with the FYDP review. Some businesses, particularly the small ones, have contended that they would prefer to do business with the commercial sector where fluctuations are not as frequent or dramatic or seemingly arbitrary. The Deputy Secretary of Defense

TABLE 3.13. SYSTEMS - CAUSES OF INCREASING LEAD TIMES

MARKET FACTORS

- Increasing competition from the commercial sector, particulary in the aerospace industry
- Decay of shipbuilding industry
- Shortages, long lead times for subsystems
- Increasing number of large multi-market conglomerates

INDUSTRY FACTORS

- Increasing age of applied technology, equipment, and facilities
- Increasing cash flow problems
- Increasing key personnel shortages
- Increasing start-up and tooling times
- Declining productivity
- Impacts of energy shortages
- Quality Assurance (QA) problems
- Lack of concern for the Defense Priorities System (DPS) and the Defense Materials System (DMS)

GOVERNMENT FACTORS

- Continuing lack of stability in DoD's Five Year Defense Plan (FYDP)
- Declining and fluctuating defense procurements
- Increasing levels of program review
- Increasing weapon system complexity
- Pushing the state-of-the-art
- Increasing application of Military Specifications (MIL-SPECs)
- Inadequate PM-Contractor communications
- Inadequate PM-User communications
- Inadequate program tracking
- Continuing inadequate emphasis and funding of DoD Manufacturing Technology (MANTECH) Program
- Lack of enforcement of the Defense Priorities System (DPS)
- Inadequacies of the Defense Materials System (DMS)

TABLE 3.14. SYSTEMS - ALTERNATIVES FOR REDUCING LONG LEAD TIMES

PROGRAM MANAGER COGNIZANCE

- Consider using advance procurement funding
- Evaluate trade-offs between MIL-SPEC items and commercial off-the-shelf items
- Ensure adequate front-end planning
- Improve communications with the User and Contractor
- Establish a "time" tracking project
- Implement and monitor the Defense Priorities Systems (DPS) if appropriate
- Encourage design stability
- Propose use of multiyear procurements
- Evaluate specification needs, including subsystems, components, and materials identified as long lead time items
- Consider combined procurements of end items, spares, and repair parts
- Control engineering change proposals
- Consider use of contract incentives for increased capitalization, productivity, and quality assurance

DOD COGNIZANCE

- Promote multiyear funding and advance procurement funding
- Evaluate the DoD Manufacturing Technology (MANTECH) program
- Promote the application of the DPS and DMS at the PM level
- Encourage the enforcement of the DPS and DMS by the Department of Commerce
- Encourage the Department of Commerce to include in the DMS all materials periodically identified as critical to the acquisition of major weapon systems
- Implement a viable system for tracking and disseminating information on long lead time items

GOVERNMENT COGNIZANCE

- Make provisions for energy allocations in time of shortages
- Reevaluate effects of OSHA/EPA regulations on defense industries
- Reevaluate taxation and depreciation policies

TABLE 3.14. SYSTEMS - ALTERNATIVES FOR REDUCING LONG LEAD TIMES (continued)

GOVERNMENT COGNIZANCE (continued)

- Establish government subsidized training programs for critical labor skills
- Promote industry involvement in national security needs

INDUSTRY COGNIZANCE

- Increase attention to product quality
- Promote in-house and on-the-job training programs for critical labor skills
- Invest in applied technology, equipment, and facilities in light of potential future profits and national security needs
- Increase communications with Program Manager and staff
- Increase communications with subcontractors and suppliers
- Increase subcontractors and suppliers incentives
- Work with Program Manager to allow for proper planning, scheduling, and budgeting
- Work with subcontractors to keep apprised of impending problems
- Increase emphasis on R&D, innovation
- Increase knowledge of market conditions to allow for better planning
- Consider wider use of off-the-shelf commercial subsystems and components
- Stockpile critical subsystems, components, and materials
- Consider advance procurement of long lead items
- Explore possible use of substitute materials

issued a memorandum recently that provides policy guidance regarding the expanded use of multiyear procurement (Ref. 12).

The Defense Systems Acquisition Review Council (DSARC) process, with each Service having its own Service Systems Acquisition Review Council (SSARC), as well as other review levels, has extended the decisionmaking process. Adding the Mission Element Need Statement (MENS) resulted in the requirement for another review cycle with its adverse effect on the acquisition process. Recently, the Deputy Secretary of Defense issued a memorandum advising that the current four DSARC decision milestones will be reduced to two. However, the Secretary of Defense will still be involved in major program initiation and improved program definition for program go-aheads (Ref. 13).

Concerned with the threat and eager to use new technology, practically every new weapon system is more complex than its predecessor. In many cases, in order to achieve the needed sophistication, the state-of-the-art must be pushed to the furthest extent possible. In many instances, this has meant increased research and development time and increased testing requirements. In addition, to achieve the sophistication needed in advanced technology, more emphasis has been placed on the application of Military Specifications (MIL-SPECs). Opinions have been expressed that in certain cases the application has been excessive and has contributed to increasing lead times through the need to meet increased tolerances, complexity, manufacturing difficulty, etc. It has been suggested that in certain cases, off-the-shelf items would have provided adequate reliability, equivalent to a MIL-SPEC item without the additional effort and time required to produce the item.

With the increased complexity came the need for more front-end planning, and more frequent PM and Contractor communications, as well as PM and User communications. The inadequacies of these interfaces have been cited as causes for the increased number of engineering changes that occurred during the past decade.

During the 1970s, with the emphasis on costs, less attention was made to tracking the acquisition process through the use of networking techniques by the PMs in both DoD and industry (Ref. 14). The use of the Cost/Schedule

Control System Criteria (C/SCSC) measures variances between planned and actual in terms of dollars rather than time (Ref. 15). This lack of attention to time has allowed the addition of small time increments that may not be noticed until a cumulative impact finally directs attention to the problem months after action should have been taken.

As mentioned previously, the declining rate in the growth of productivity has been a factor identified as a cause of increasing lead times. Part of the reason for the decline has been the continuing growth of aging technology in industry. Recognizing the need for industry to improve its manufacturing techniques as early as the 1950s, the Air Force commenced a Manufacturing Technology (MANTECH) program. Similar efforts were started by the Army and the Navy in the 1960s. The objectives of the program were to develop or improve manufacturing processes, techniques, materials, and equipment to provide timely, reliable, and economical production of defense materials. As DoD has been increasing emphasis and funding of MANTECH throughout the 1970s, industry has acknowledged that the program should prove beneficial in the long run. However, industry has also made the following criticisms, many of which have so been cited in the Comptroller General's report to the Congress (Ref. 16):

- The MANTECH program is too diversified
  - there are too many projects (currently over 600)
  - project objectives are not adequately defined
  - projects are not prioritized.

- Prime contractors appear to be main recipients of the program.

- Technology developed is not always disseminated as adequately as it should be, particularly down to the second and third tiers of industry.

Accordingly, MANTECH could more effectively contribute to solutions of long lead problems in major weapon systems acquisition (Refs. 11, 17). Portions of the above discussion are also relevant to the Technology Modification (TECH MOD) program (Ref. 17).

The disregard of the Defense Priorities System (DPS) has been cited as a cause of increasing program schedules in the 1970s. In some cases PMs have not rated programs that should have been rated to ensure priority treatment. In others that were rated, it has been noted that ratings, particularly DO ratings, have been disregarded to varying degrees by contractors or suppliers, or ratings have not been disseminated to subcontractors and suppliers. There has been little or no monitoring or enforcement of the DPS. Such actions could prove to be beneficial in improving program schedules.

The problems with the Defense Materials System (DMS) are similar to those discussed above for the DPS, with an additional factor. The DMS is concerned with the control of only four processed materials consisting of aluminum, copper, nickel, and steel alloys (Ref. 18). As has been discussed in the sections on raw and processed materials, there are more than a dozen other materials that are considered critical to major weapon systems acquisition and should be considered for inclusion in the DMS.

3.3.5.2 Alternatives for reducing long lead times. Alternatives for reducing lead times of systems must, of course, encompass the alternatives proposed for subsystems, components, processed material, and raw material as discussed in previous sections and listed in Tables 3-12, 3-9, 3-6, and 3-3. Some of the major alternatives cited for the lower stratification of the systems requirements are reiterated in the listing of alternatives for systems in Table 3.14. Section 4 will discuss the feasibility of applying the alternatives.

3.3.6 Services. For this research effort, one field of endeavor has been classified as a service since it benefits various aspects of major weapon systems acquisition. As illustrated in Table 3.15, Research and Development (R&D) has been identified as having caused increasing lead times during the 1970s. With the continuing increase in the complexity and sophistication of weapon systems during the past decade, additional R&D has been required to achieve the state-of-the-art desired. Causes identified as contributing to increasing lead times are listed in Table 3.16 and are discussed in the following section. Alternatives for reducing long lead times are presented in Table 3.17 and are discussed in Section 3.3.6.2.

TABLE 3.15. SERVICES

SERVICE	SYSTEM APPLICATION									
	Aircraft	Electronic/ Optical Equipment	Helicopters	Missiles	Weapons	Simulators	Ships	Submarines	Test Equipment	Armored Vehicles
Research & Development	X	X	X	X	X	X	X	X	X	X

TABLE 3.16. SERVICES - CAUSES OF INCREASING LEAD TIMES

MARKET FACTORS

- More emphasis on commercial Research and Development (R&D) rather than Defense R&D
- Increasing demand for more Defense R&D

INDUSTRY FACTORS

- Capital investment in R&D constrained by inflation, the high cost of money, unfavorable tax policies, and management priorities
- Increasing shortage of engineers and technicians

GOVERNMENT FACTORS

- R&D requirements for advancing state-of-the-art
- Increasing expenditures for R&D in early 1970s
- Need for refining R&D priorities

TABLE 3.17. SERVICES - ALTERNATIVES FOR REDUCING LONG LEAD TIMES

PROGRAM MANAGER COGNIZANCE

- Define realistic R&D objectives
- Ensure that realistic R&D schedules are established
- Improve communications with the user and contractor

DOD COGNIZANCE

- Define R&D priorities for more emphasis in urgent need areas
- Consider alternatives to state-of-the-art R&D such as pre-planned product improvements
- Promote use of small firms and independent inventors in defense R&D efforts either directly or through subcontracts with prime contractors

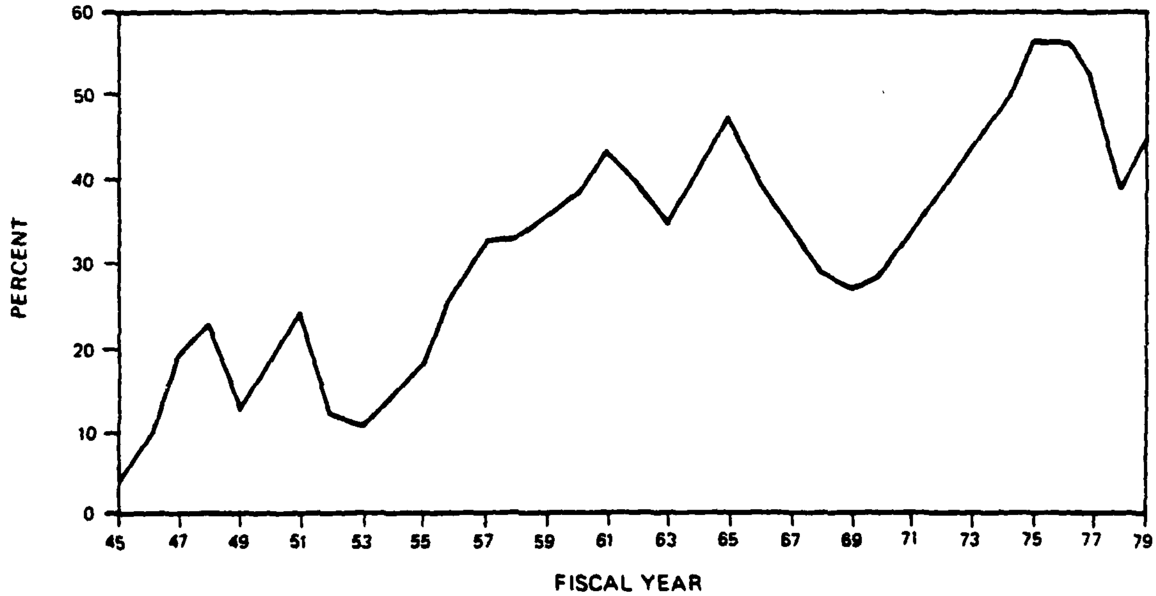
GOVERNMENT COGNIZANCE

- Encourage industry to conduct defense related R&D
- Encourage use of small firms and independent inventors in defense R&D efforts
- Establish government subsidized training programs for engineers, technicians, programmers, analysts, and other critical skills

INDUSTRY COGNIZANCE

- Promote in-house and on-the-job training programs for critical skills
- Increase communications with Program Manager and staff to ensure realistic schedules, plans, and budgets
- Consider subcontracting portions of defense R&D effort with small firms and independent inventors

3.3.6.1 Research and Development (R&D). With the expanding economy of the '70s, R&D was becoming increasingly oriented to the commercial market in an effort to meet or exceed the high technology evidenced in commodities from foreign competition. At the same time, specifically from 1969 to 1975, DoD increased its outlay of R&D dollars, as a portion of the DoD total procurement outlay, from less than 30 percent to more than 55 percent (see Figure 3.10) (Ref. 19). This combined increase in R&D efforts also compounded the increasing shortage of engineers and technicians. Further, capital investment in R&D equipment and facilities were constrained by the spiraling inflation rate, the increasing high cost of money, unfavorable tax policies and management priorities.



From: Gansler, Jacques S. The Defense Industry

Figure 3.10. Ratio of R&D Outlays to Procurement Outlays for Defense. (In terms of constant 1976 dollars)

Not only did the above factors cause increasing R&D lead times, but as needs for more complex and sophisticated major weapon systems increased during the past decade, R&D efforts had to increase in size and scope to achieve the required state-of-the-art. This again increased the lead time for R&D as

greater uncertainties were encountered. In addition, as the size of the R&D efforts increased, more small firms were incapable of performing the required R&D effort and the defense R&D effort became more and more concentrated in large firms (Ref. 19).

3.3.6.2 Alternatives for reducing long lead times. The alternatives proposed for reducing lead times for R&D are listed in Table 3.17. An underlying factor in R&D is that lead time is directly related to the complexity and sophistication of the end product. Section 4 will discuss the feasibility of applying the alternatives.

4. ALTERNATIVES FOR IMPROVING OR ELIMINATING LONG LEAD TIME PROBLEMS

4.1 Discussion. As each category of long lead items was discussed in the previous section, related causes for increasing lead times were also discussed and alternatives for alleviating increasing lead times were presented (see Tables 3-3, 3-6, 3-9, 3-12, 3-14, and 3-17). This section will discuss the feasibility of implementing the alternative courses of action that are considered within the cognizance of the Program Manager, DoD, Congress or other Government departments, and industry. The alternatives have also been categorized as to the potential effect their implementation would have on improving lead times.

4.2 Program Manager Cognizance. Table 4.1 lists alternative courses of action that are considered feasible and within the cognizance of the Program Manager. Except for a few alternatives that require action by higher authority, most of the alternatives should be totally within the PM realm of responsibility.

4.2.1 Multiyear and advance procurement funding. The use of multiyear and advance procurement funding has been proven to be beneficial in reducing lead times. Multiyear procurements reduce the fluctuations encountered in single year procurements, and provide stability for planning, development, and production. Advance procurement funding provides contractors with the financial resources with which to purchase long lead items, such as raw material, components, etc., earlier than would be possible under regular procurement action. It is acknowledged, however, that use of advance procurement funding is not a panacea for long lead time problems, but its use can be of benefit in certain cases. Further, advance procurement requires better communications with industry and detailed planning, budgeting, and knowledge of market conditions. The probability of obtaining increased use of these two beneficial funding techniques will be discussed in Section 4.3.

TABLE 4.1. FEASIBILITY OF ALTERNATIVES - PROGRAM MANAGER COGNIZANCE

ALTERNATIVE	LEAD TIME IMPROVEMENT POTENTIAL	IMPLEMENTATION REQUIRES HIGHER LEVEL ACTION
• Propose use of multiyear procurements	High	Yes
• Improve front-end planning	High	-
• Improve communications with Users and contractors	High	-
• Propose use of advance procurement funding	Medium	Yes
• Understand the business environment within which their acquisition occurs	Medium	-
• Establish early design stability	Medium	-
• Implement and monitor DPS rating	Medium	Yes
• Establish a "time" tracking project such as PERT, CPM	Medium	-
• Include contract provisions and/or incentives for increasing capitalization, productivity, and quality control	Medium	-
• Combine purchases of end items, spares and repair parts	Medium	-
• Conduct trade-off studies	Medium	-
- Mil-Spec vs commercial items	Medium	-
- Use of substitute materials	Low	-
• Define realistic R&D objectives	Low	Yes
• Establish realistic schedules for R&D	Low	-
• Implement and monitor DMS rating	Low	Yes

4.2.2 Improve front-end planning. This alternative has always been acknowledged as practically a statement of fact. The more complete the initial planning, the fewer problems encountered afterwards. It is proposed that during this early planning phase, benefits can be gained by assessing the business environment to identify potential long lead time problems, and consider these in the program acquisition strategy and in the system design and specifications. Also in this respect, realistic R&D objectives should be defined and it should be acknowledged that extending the state-of-the-art is more difficult to achieve than R&D within the state-of-the-art. Naturally, the earlier system designs and requirements can be stabilized, the greater the benefits gained in development and production by reducing the impacts of engineering changes. Similar benefits accrue in early definition and stabilization of software requirements. Also, a concerted effort to conduct trade-off studies to determine if commercial off-the-shelf items can be used instead of Mil-Spec items could produce considerable savings in procurement lead time. If off-the-shelf items are also identified as critical long lead items, the trade-off studies should evaluate the possibility of other substitutes (Ref. 1).

4.2.3 Improve communications with Users and contractors. The benefits of a Program Manager improving communications with the Users and contractors throughout program acquisition can prove to be highly significant in improving lead times. A considerable number of major weapon systems acquisitions during the past decade had numerous engineering changes and rework efforts caused by inadequately defined objectives, designs, and requirements. Many of these problems have been traced to the lack of User involvement in front-end planning, and to the lack of both the User and contractor involvement in the decisionmaking process of an acquisition. Better communications between PMs and industry can benefit planning and budgeting through the combined knowledge of government and industry regarding raw and processed materials, components, etc., that could lead to improved system design, development, and production.

4.2.4 Implement and monitor DPS and DMS ratings. Program Managers should insure that if their programs qualify for Defense Priorities System (DPS) and/or Defense Materials System (DMS) ratings, all procurement documentation directed to contractors, sub-contractors, and suppliers should carry the

designations and ratings. As discussed in Section 3, it is apparent that there is evidence of disregard of both the DPS and the DMS, particularly at the lower industrial tiers when the economy and commercial orders provide adequate business. In certain cases this disregard has resulted in the DPS and DMS ratings not being disseminated to the lower tiers and suppliers, where long lead times are critical and severely impact on the production of the major weapon systems. There is a definite need to periodically monitor the contractors and lower tiers and suppliers to encourage their compliance, and to advise the Department of Commerce regarding repeated and willful violations (Ref. 2).

4.2.5 Establish a "time" tracking project such as PERT, CPM. Although management tracking systems were all the vogue in the 1960's, interviews conducted during this research and recent study reports have indicated that Program Managers have not been utilizing the techniques as frequently or effectively as in the past. PMs should establish and monitor a management tracking system for their programs and should include critical long lead items, or establish a separate tracking system specifically for critical long lead items.

4.3. <u>DOD Cognizance</u>. Alternatives within the cognizance of DoD are listed in Table 4.2, and are considered feasible with the possible exception of one, alternatives to state-of-the-art development. Such an alternative could help improve the long lead time problem by decreasing the risks and uncertainties of R&D, thus decreasing the time involved in R&D efforts, as well as the time in development and production of highly sophisticated state-of-the-art weapon systems. Alternatives to state-of-the-art development in the most cases are not practical since the main objective of defense development is to advance the state-of-the-art and develop new technology breakthroughs to continually improve our national security posture and to insure that we can respond to any threats of foreign aggression. However, the pre-planned product improvement approach is very viable to major platforms composed of replaceable subsystems.

TABLE 4.2. FEASIBILITY OF ALTERNATIVES - DOD COGNIZANCE

ALTERNATIVE	LEAD TIME IMPROVEMENT POTENTIAL	IMPLEMENTATION REQUIRES HIGHER LEVEL ACTION
• Increase use of multiyear procurements	High	Yes
• Increase use of advance procurement funding	Medium	Yes
• Establish a viable system to track long lead items and to disseminate data	Medium	-
• Consider alternatives to state-of-the-art development, such as pre-planned product improvements	Medium	-
• Promote adequate up-front planning to improve program stability	Medium	-
• Promote use of small firms and independent inventors in defense R&D efforts either directly or through subcontracts with prime contractors	Medium	-
• Promote combining of end-item, spares, and material requirements to increase order quantities	Medium	-
• Promote use of incentive type contracts to improve quality and timeliness of end products	Medium	-
• Define R&D priorities for more emphasis on critical long lead items	Low	-
• Evaluate MANTECH program emphasis	Low	-
-increase MANTECH program funding	Low	-
-assess aerospace and shipbuilding foundry and milling compatibility	Low	-
• Promote the application and monitoring of the DPS and DMS	Low	-
• Request enforcement of DPS and DMS by the Department of Commerce	Low	Yes
• Request Department of Commerce to include all acquisition critical raw and processed materials in DMS	Low	Yes
• Review contractor requirements for data and documentation for possible reductions	Low	-
• Incentivize industry to conduct defense related R&D	Low	-

4.3.1 Increase use of multiyear and advance procurement funding. Multiyear and advance procurement funding have proven to be very beneficial in alleviating many of the problems of long lead times in major weapon systems acquisition. The multiyear procurements improve production processes by providing for longer runs of known quantities, decreasing financial borrowing costs, and reducing administrative burden in contracting. A risk associated with multiyear procurements is that Congress might rescind a program's funding authorization in a subsequent year that would result in a termination liability expenditure. However, if a program has been well planned and executed, and its mission essentiality firmly justified, the benefits should outweigh the risk. Use of advance procurement funding allows for early purchases of critical long lead items that have assisted in reducing some of the long lead time problems. Deputy Secretary of Defense (DepSecDef) recently issued a memorandum to top DoD officials stating that DoD is determined to improve the acquisition process by, among other things, encouraging PMs to develop acquisition strategies that include the multiyear and advance procurement funding concepts. DepSecDef advised in his memorandum that many improvements in the acquisition process can be accomplished in-house; however, others would require legislative consideration and action. Congressional action would, of course, be required to authorize increased use of multiyear and advance procurement funding (Ref. 3).

4.3.2 Establish a viable long lead item tracking system. There is a need to establish a viable long lead item tracking system for use by Program Managers and other cognizant personnel, commands, activities, and offices. Standard categories of long lead items need to be developed, as do nomenclature and procedures for collecting, analyzing, and retaining data. A viable tracking system would also provide a sound basis for subsequent forecasting and periodically provide PMs with the current and projected trends for planning purposes. The system, of course, should also track economic indices, socioeconomic events, etc., and develop relationships that would improve forecasting techniques and accuracy. Although this study proposes the establishment of a long lead item tracking system under the cognizance of DoD, several questions remain to be resolved, such as:

- At what level, agency, or office should the system be established?

- Should current efforts by the Joint Aeronautical Materials Activity (JAMAC), the Materiel Development and Readiness Command (DARCOM), the Navy Shipbuilding Scheduling Office (NAVSHIPSO), and the Defense Logistics Agency (DLA) be centralized in a DoD long lead item tracking system office?

- To what extent should other government agencies and industry be involved?

4.3.3 Consider alternatives to state-of-the-art development. As indicated in Table 4.2, implementing this alternative could have considerable potential for improving lead times; however, as discussed in Section 4.3, actually *pursuing* the alternative in the greater majority of cases is not plausible. One approach to this alternative that could prove highly beneficial is preplanned product improvement through which systems are created in modular form to facilitate maintenance and subsequent upgrading of the systems. Preplanning for state-of-the-art enhancement will not only reduce future lead times but will also provide for beneficial cost savings.

4.3.4 Define R&D priorities for more emphasis on critical long lead items. There is a decided need for more R&D to develop substitutes for critical long lead items that could replace raw materials and processed materials, particularly various alloys. At the present time many of the current substitutes are petroleum based and are also considered critical from that standpoint.

4.3.5 Use MANTECH to reduce need for short-supply labor skills. The Comptroller General's Report to Congress in September 1979 (Ref. 4) also suggested that DoD should reevaluate the MANTECH program. Although efforts in this direction have been made, particularly by the Services, additional attention is needed. As mentioned in Section 3, more MANTECH program emphasis should be directed to the manufacturing processes of the lower tiers of the industrial defense base. Particular emphasis should be placed on highly labor intensive areas such as foundry and milling operations, which are also large contributors to the increasing lead times encountered in the 1970s. Further, as mentioned in Section 3, there is a fairly distinct stratification within

the defense industrial base, even at the lower tiers, between aerospace and shipbuilding industries. For example, industries providing castings and forgings for aerospace are functioning at near capacity limits, whereas similar industries providing similar products for shipbuilding are not as severely impacted and have shorter lead times.

Doty Associates suggested that an alternative for alleviating some of the long lead time in castings and forgings would be to have foundries and milling firms oriented towards shipbuilding use their extra capacity to assist with the aerospace industry backlogs. However, in contacting industry representatives during this research effort, they advised that the suggestion was not feasible because shipbuilding industries were not as experienced in working with certain aerospace material, nor with the tight tolerances and specifications required in aerospace products. Regardless of the above comment, it is proposed that the intersector support flexibility, including in-house DoD, be pursued under the MANTECH/TECHMOD program.

Although the overall funding of DoD's MANTECH program has been increasing annually, it is proposed that DoD consider increasing the MANTECH program to approximately 1.5 percent of the defense procurement budget for the next 3 to 5 years. The additional funding should be specifically directed to the most rapid enhancement of productivity relative to alleviating the increasing lead times that have been and are being experienced. In this regard, manufacturing technology with broad application potential should be emphasized rather than narrow specialty technology.

4.3.6 Promote the application and monitoring of the DPS and DMS. DoD should encourage the use and application of the DPS and DMS. Further, PMs should be encouraged to conduct periodic monitoring (see Section 4.2.4), and DoD should insure that DCASRs audit and aggressively report repeated offenders to DoD and the Department of Commerce.

4.3.7 Request enforcement of DPS and DMS by the Department of Commerce. Upon being advised of any repeated violations of the DPS or the DMS, DoD should request the Department of Commerce to assist firms to better understand the two systems or to determine if enforcement is needed in the case of willful violations.

4.3.8 Request that the Department of Commerce include in the DMS all acquisition critical raw and processed materials. Currently, the DMS only includes four processed materials: copper, steel, aluminum, and nickel alloys (Ref. 2). As discussed in Section 3, both critical raw and processed materials cause increasing lead times. It is proposed that DoD request the Department of Commerce to consider including other identified critical processed materials in the DMS and also consider the inclusion of critical raw materials. It is also suggested that subsequently DoD periodically advise the Department of Commerce of those materials that are identified as critical or are no longer critical to the acquisition of major weapon systems.

4.3.9 Promote combining of material requirements to increase order quantities. Increased order quantities mean larger and longer production runs and thereby provide stability in industry. Tooling and setup times are reduced and productivity is increased, as well as the potential for improved quality and reliability. These factors in turn can result in an overall decrease in lead times.

4.3.10 Review contractor requirements for data and documentation for possible reductions. One of a number of reasons cited by various firms for their reluctance to do business with DoD or for their departure from the defense industrial base, has been the paperwork involved in government procurements. Small businesses and lower tier firms have particularly stated their concerns in this area. Thus, the shrinking defense industrial base has contributed to increasing lead times. Accordingly it is proposed that DoD evaluate data and documentation requirements for contractors, and implement appropriate reductions.

4.3.11 Promote use of incentive type contracts to improve quality and timeliness of end products. Since defense procurements are, in a sense, competing with commercial procurements in the market place, offering the opportunity for increased profits could stimulate interest in DoD procurements. Benefits can be accrued from a DoD standpoint, through potential improvements such as increased productivity, improved quality, and tighter schedules. Accordingly, these benefits would assist in alleviating long lead time problems.

4.4 Congress or Other Government Departments Cognizance. The alternatives that are considered within the cognizance of Congress or other government departments are listed in Table 4.3. With the current administration's emphasis on improving our economy and defense posture, plus the recent Congressional hearings on our minerals vulnerability (Ref. 5) and our ailing defense industrial base (Ref. 6), Congress should be amiable to favorably consider legislation that could benefit both the economy and the defense posture. Accordingly, the proposed alternative actions by Congress for alleviating long lead times are considered feasible to varying degrees, with the unfortunate possible exception of the subsidized training programs. Naturally, the scope of each of the proposed legislative actions will depend on Congress, their constituents, lobby groups, Executive Branch influence, etc. and the efforts of DoD to persuade and convince Congress and other government departments that appropriate actions are necessary for our national security. Most of the alternatives listed in Table 4.3 are relatively self-explanatory and their potential impact on lead times in major weapon systems acquisition has been discussed previously in this report; however, the following two clarifications are provided regarding the establishment of an effective energy allocation system and the reestablishment of a revolving fund under Title III of the Defense Production Act of 1950.

4.4.1 Establish an effective energy allocation system. The energy crises of the 1970s affected lead times of weapon systems acquisition either directly or indirectly. There is a need to establish an effective energy allocation system that can be implemented in times of energy shortage and would insure that defense industries are not critically effected. A program for priorities and allocation of selected energy resources was recently promulgated by Department of Commerce letter dated 11 May 1981 (Ref. 7), which established a program to assist contractors experiencing difficulty in obtaining supplies of materials and equipment critical to projects that will maximize domestic energy supplies. This program may indirectly benefit defense industries in the future by reducing the impacts of energy crises through the increase or availability of domestic energy. However, what is needed is an energy allocation system that could directly benefit defense industries to insure that adequate energy is available for the processing of raw materials, production operations, and transportation.

TABLE 4.3 FEASIBILITY OF ALTERNATIVES - CONGRESS OR OTHER GOVERNMENT DEPARTMENTS COGNIZANCE - DOD ACTIVE SUPPORT

ALTERNATIVE	CONSIDERATION AND POTENTIAL	LEAD TIME IMPROVEMENT POTENTIAL	CURRENT IMPLEMENTATION POTENTIAL
• Authorize increased use of multiyear procurements	Congress	High	Medium
• Authorize increased use and duration of advance procurement funding	Congress	Medium	High
• Authorize improvement of depreciation policies	Congress	Medium	Low
• Authorize decreased corporate taxes	Congress	Medium	Medium
• Decrease OSHA/EPA regulations impact on the defense industrial base	Congress	Medium	Medium
• Authorize increased mining of public lands	Congress	Medium	Medium
• Reestablish revolving fund and promote use of Title III of the Defense Production Act of 1950	Congress	Medium	Medium
• Establish government training programs for engineers, technicians, programmers, analysts, and other critical skills	Congress	Medium	Low
• Authorize increased MANTECH program funding	Congress	Low	Medium
• Establish an effective energy allocation system	Dept. of Energy and/or Commerce	Low	Low

TABLE 4.3 FEASIBILITY OF
CONGRESS OR OTHER GOVERNMEN
COGNIZANCE - DOD ACTIVE SUPP)

ALTERNATIVE	CONSIDERATIVE AND ENT POTENTIAL	CURRENT IMPLEMENTATION POTENTIAL
• Promote reduction of paperwork required of subcontractors	Dept. of Commerce	Low
• Implement enforcement of DPS and DMS	Dept. of Commerce	Medium
• Incentivize industry to conduct defense related R&D	Congress and/or Dept. of Commerce	Low
• Encourage use of small firms and independent inventors in defense R&D efforts	Congress and/or Dept. of Commerce	Low

4.4.2 Reestablish the revolving fund and pro of Title III of the Defense Production Act of 1950. Under Title III, ernment is authorized to underwrite the expansion of domestic critical s production when the United States is substantially dependent on impor his assistance can be provided by establishing guaranteed markets, provi uaranteed loans, or by authorizing accelerated write-offs of capital ents. The Title III revolving fund was abolished in 1974, and since t Congress requires each program to be submitted to them for consideration. Defense Science Board noted in their 1980 study that very few, if any ve been authorized and funded (Ref. 8). Accordingly, it is proposed the revolving fund be reestablished and the use of Title III receive ate promotion to revitalize this highly important and needed sector of the defense industrial base.

4.5 Industry Cognizance. Table 4.4 lists e alternative courses of action that are considered within the cognizance industry. Although these alternative actions would have to be at the discretion of management, considerable encouragement would be provided by the implementation of the alternatives in Table 4.3 for proposed Congressional legislative action. All alternatives for industry cognizance are considered feasible depending on

TABLE 4.4 FEASIBILITY OF ALTERNATIVES -
INDUSTRY COGNIZANCE - DOD ACTIVE SUPPORT

ALTERNATIVE	LEAD TIME IMPROVEMENT POTENTIAL	SHORT RANGE OR LONG RANGE POTENTIAL
• Invest in applied technology, equipment, and facilities	High	Long
• Invest in and stockpile critical raw materials and other long lead items	High	Short
• Promote in-house and on-the-job training programs for critical labor skills	High	Long
• Establish program for improving product quality during production	Medium	Short
• Improve compliance with DPS and DMS ratings	Medium	Short
• Improve communications with suppliers of raw materials, components. Increase marketplace knowledge and research	Medium	Short
• Advise customer of known material problems early to allow for advance planning, budgeting, and scheduling	Medium	Short
• Explore possible use of substitute materials and wider use of off-the-shelf items	Medium	Long
• Increase subcontractors and suppliers incentives	Low	Long
• Consider subcontracting portions of defense R&D effort with small firms and independent inventors	Low	Long
• Increase emphasis on defense R&D, innovation	Low	Long

managerial priorities, cash flow, taxation policies, etc. What industry must appreciate is that investment into the improvement of the defense industrial base could improve their capability to respond to the commercial market as well.

Alternatives listed in Table 4.4 have been discussed previously in this report and are self-explanatory; however, one additional comment is appropriate regarding the alternative "Invest in and stockpile critical raw materials." During the industry interviews, one large aerospace prime contractor representative advised that much of their increasing production lead time was directly related to the shortage of raw materials at the lower tiers. Further, the prime contractor acknowledged that smaller subcontractors could not afford the investment of stockpiling. As a result, the prime contractor was initiating action to finance the stockpiling. This would reduce the expense and risk to the subcontractors and at the same time, alleviate some of the critical long lead times previously experienced. This type of cooperative action could prove to be highly beneficial in reducing lead times in major weapon systems acquisition. Actions of this type could also be incentivized by the PM/DoD through contractual agreements.

5. SUMMARY

5.1 Study Results. The results of this research study of increasing lead times in major weapon systems are summarized below:

- Items experiencing significant increases in lead times during the past decade were identified through literature reviews and interviews with personnel involved in various aspects of major weapon systems acquisition in DoD, government, and industry.

- For the purposes of this study, items were classified in six categories. The numbers in parentheses indicate the number of items identified:

- Raw Materials	(17)	- Subsystems	(27)
- Processed Materials	(10)*	- Systems	(10)**
- Components	(54)	- Services	(1)

- Items with lead time data were analyzed for trends and 124 trend charts were prepared and are included in Appendix E. The data analysis also revealed distinct differences in the lead times for aerospace, armored vehicles, and shipbuilding items.

- Items that were identified as having the most significant increases in lead times during the past decade were bearings, castings, forgings, and integrated circuits. Assessments of the long lead time problems of these items are presented in Appendices B through D.

- Major causes associated with each classification of long lead items were grouped by category of influence, such as government factors, industry factors, or market factors. Some of the more significant causes of increasing lead times are:

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* Processed materials were subcategorized into ten types such as bars, extrusions, plates, etc., and each of these were identifed by the material used; for example, aluminum bar, titanium extrusion, or steel plate.

** Systems were subcategorized generically only.

- Government

  . The lack of stability in major weapon systems acquisition resulting from annual funding, insufficient front-end planning, and communications.

- Industry

  . The lack of investment in and stockpiling of critical raw materials and other long lead items.

  . The lack of investment in applied technology, equipment, and facilities.

  . The shortage of engineers, technicians, and other skilled craftsmen.

- Market

  . The significant competition of commercial demands in certain business sectors such as aerospace and electronics.

● Based on analyses of the causes in each classification of increasing lead time items, alternative courses of action were proposed for alleviating the long lead time problems. Alternative courses of action were identified as within the cognizance of PMs, DoD, Congress, or other government departments, and industry. The following proposed courses of action would be most beneficial in reducing the impacts of the more significant causes cited above:

  - Increase the use of multiyear procurements to reduce the fluctuations being experienced in many single year funded programs.

  - Improve front-end planning and stabilize the design as much and as early as possible to reduce the impact of changes.

  - Improve communications between Users, PMs, and contractors in order to provide a better understanding of the details and overall aspects of a program and thus insure better planning, budgeting, and scheduling.

  - Increase business incentives such as decreased corporate taxes to encourage investment in and stockpiling of critical raw materials and other long lead items. Also increase use and duration of advance procurement funding.

  - Promote investment in applied technology, equipment, and facilities through increased business incentives, including improvements of depreciation policies, reduced taxes, and increased MANTECH program funding.

- Establish in-house and on-the-job training in industry, and establish government training programs for engineers, technicians, and other critical skills.

- Develop a better understanding of the business environment in which the acquisition takes place in order to improve planning, budgeting, and scheduling.

5.2 Need for Further Study. Included in the alternatives presented in this report are a number of ideas that need further study and consideration.

- Develop a viable long lead item tracking system (see Section 4.3.2), including:

  - identify items to be tracked by standard nomenclature,

  - develop procedures for collecting, analyzing, retaining, and disseminating data,

  - develop long lead item forecasting techniques incorporating economic indices, socioeconomic events, etc.

- Evaluate the potential for intersector, i.e. aerospace and shipbuilding, support flexibility (see Section 4.3.5).

- Evaluate data and documentation requirements imposed on contractors to determine what can be simplified, reduced, or eliminated (see Section 4.3.10). Paperwork involved with government procurement is the primary reason that small firms are reluctant to do business with government.

APPENDIX A

AN OVERVIEW OF CRITICAL RAW MATERIALS

Although numerous causes have been cited for increasing lead times for major weapon systems acquisition during the past decade as discussed in Section 3, one of the basic driving forces in delays and schedule slippages during development and production can be tracked back to the availability and use of certain raw materials. Accordingly, an understanding of raw materials that have been identified as critical to the acquisition of major weapon systems could prove beneficial to Program Managers (PMs) in making better planning assessments and scheduling decisions.

To assist in this understanding, this Appendix provides overviews of the following critical raw materials. Additional information may be obtained from the most recent editions of the citations listed in the Reference Listing for this appendix and from the Commodity Specialists of the Bureau of Mines, Department of Interior.

ALUMINUM (Refs. 1, 2, 3, 4, 5)

Description and Uses. Aluminum is a light-weight metal that, while being the most abundant metal element in the earth, does not occur naturally. The first step in aluminum production uses the plentiful ore bauxite. Bauxite ore is surface mined and then subjected to chemical processes to extract alumina (aluminum/oxygen compound). Aluminum metal is produced by reduction of the alumina by electrolysis in a molten solution of fluoride salts. Standard metallurgical techniques are then used to make various forms of aluminum such as bar, sheet, and foil.

Aluminum has many desirable characteristics that make it a widely used metal, including its strength, low weight, resistance to corrosion, and electrical conductivity. Major uses are in packaging, construction, and transportation, with particular applications in aircraft, ships, and missiles.

Supply. The U.S. produces enough aluminum to meet domestic demand and in fact exports 25% of its production of the material. Recycled aluminum accounts for about 12% of the supply. Imports of the raw materials, bauxite and alumina, account for 93-94% of U.S. aluminum producers' supply with the major exporting nations being Australia and Jamaica. World resources of bauxite are considerable. Including all aluminum bearing ores that could be mined, the supply is virtually inexhaustible. U.S. bauxite reserves are small, but increasing attention is being paid to extracting aluminum compounds from plentiful ores such as clays and shales.

Future domestic production of aluminum metal depends on the availability of inexpensive electric power or technological advances in decreasing the energy requirements of alumina reduction.

Demand. Demand for aluminum is expected to increase at an average annual rate of 5.3% over the next twenty years. Increasing use of aluminum in transportation equipment is anticipated to take advantage of weight savings. In containers, aluminum demand will depend on prices for competing materials such as glass and plastics. In electrical applications, including communications, aluminum demand should increase with growth of the underlying industries.

The U.S. consumption trend for aluminum from 1965 to 1980 is shown in Figure A-1.

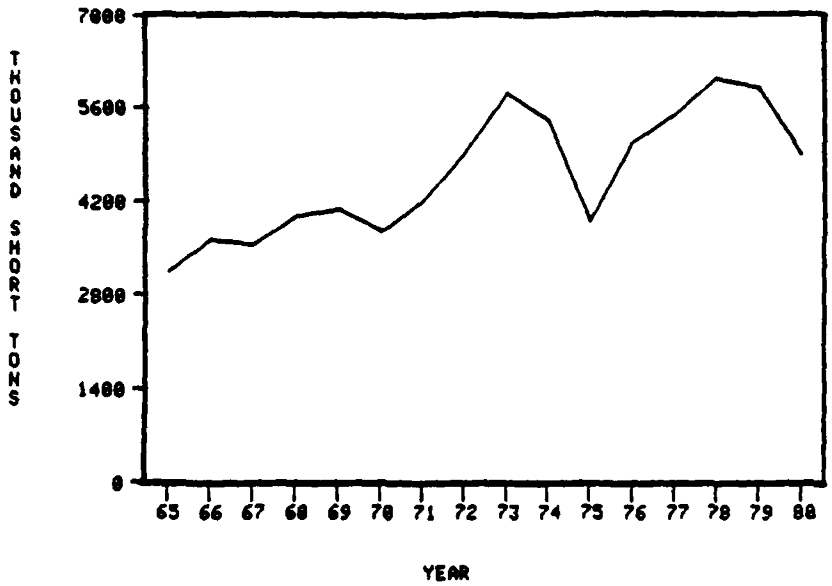

Figure A-1. Aluminum Consumption.

Substitutes. Where light-weight strength is required, in aircraft for instance, magnesium and titanium may be substituted for aluminum. As a basic construction material, aluminum is generally subject to substitution by steels, woods, plastics, and other structural materials. In electrical applications, copper can be substituted for aluminum.

Substitution for bauxite to obtain alumina is currently being researched. Most likely candidates include clays, anorthosite, and oil shale.

ASBESTOS (Ref. 3)

Description and Uses. Asbestos is a fibrous mineral found in different forms in the earth's crust. Asbestos-bearing rock is mined in an open pit or underground, air-dried, then screened. A complex milling procedure takes place to separate the fiber from rock and to classify the fiber by length. Finally, the raw material is further refined for various applications.

When processed into fiber, asbestos is adaptable to many uses. Due to its high strength to weight ratio and heat resistance, asbestos is particularly useful in jet engines, marine turbines, and missiles. Other applications include fire-retardant construction materials, brake linings, and cable insulation.

Supply. While the U.S. has some domestic production of asbestos, the majority of our consumption (85%) is supplied by Canada. Canada is the world's second largest producer of asbestos behind the Soviet Union. U.S. and Canadian resources are more than ample to meet expected U.S. demand through the year 2000.

Special grade, low iron, long-fiber asbestos is available only from Southern Africa, principally Zimbabwe (formerly Rhodesia). This grade of asbestos, used mainly in the manufacture of electrical insulation, cannot be obtained elsewhere.

Demand. U.S. asbestos demand has decreased in the past two years due to increasing legislative concern over the health hazard aspects of the material. Overall, U.S. demand should be steady at a near zero rate through the next twenty years, according to estimates currently being made by the Bureau of Mines. World demand will grow at a much higher rate than domestic demand due to higher construction potential in developing nations. As a general trend, demand parallels cyclical economic indicators for construction and transportation equipment.

Substitutes. There are no wholly satisfactory substitutes for asbestos although some progress has been made recently using glass fibers in construction applications. Future substitutes may be developed, particularly in light of the environmental health problems associated with asbestos usage. Synthetic asbestos has been developed, but is not economically attractive at this time.

Recycling. No significant amount of asbestos can be recycled.

BERYLLIUM (Ref. 6)

Description and Uses. Beryllium is a high-strength, lightweight metal with excellent anticorrosion characteristics. Beryllium-bearing rock is mined as a coproduct of mica and feldspar mining. Through a heating, evaporation, and chemical process, the beryllium is extracted, and is then smelted to produce metallic beryllium or various alloys.

Due to its intrinsic properties, beryllium is used in aerospace applications such as aircraft brake discs, airframes, and inertial navigational systems for missiles and aircraft. The majority of beryllium, however, is consumed as a copper alloy with applications in communications, computers, and switching devices. Beryllium also has good neutron deflecting capabilities and finds uses in nuclear reactors, including use as fuel container material.

Supply. Domestic production of beryllium is anticipated to satisfy current and future demand patterns. One company in Utah supplies nearly all beryllium consumed in the U.S. Domestic resources (primarily in Utah), as well as world resources, are more than adequate to fill future needs.

Demand. Because of the relatively expensive nature of beryllium processing, demand is modest, and is exceeded by known reserves. U.S. demand is expected to grow at a very low rate (less than 1% annually) through the year 2000 and world demand should increase at a similar rate.

Substitutes. Steel, titanium, and graphite can be regarded as substitutes for metallic beryllium. New composite materials being developed, such as those containing boron or graphite fibers, may prove an even better substitute. For certain military uses, particularly in microwave applications, there is no known substitute.

Recycling. It is not currently cost effective to recycle old beryllium scrap.

CADMIUM (Refs. 5, 7)

Description and Uses. Cadmium is a heavy metal produced as a byproduct of zinc smelting. Because of its good electrical properties, cadmium is used in batteries and in special plating applications. Future development of photovoltaic solar cells using cadmium compounds is anticipated.

Supply. Domestic production of cadmium accounts for less than 40% of U.S. consumption. The majority of imported cadmium comes from Canada, Mexico, and Australia. World resources of cadmium are directly tied to those of zinc, and appear sufficient to meet future demand.

Demand. U.S. demand for cadmium is expected to grow at an annual rate of 1.8% through 1990. A major component of this demand will be determined by the extent to which cadmium is used in solar energy applications. A sizable increase in demand also depends on the future of electric transportation.

Substitutes. Zinc coatings can be substituted in many plating applications.

Recycling. Recycling of cadmium has proven practical only for nickel-cadmium batteries.

CHROMIUM (Refs. 4, 6)

Description and Uses. Chromium is a steel gray metal that is contained in the earth in the form of chromite ore. Mining of chromite by traditional methods is followed by cleaning and screening to produce a concentrated substance. Smelting takes place in the metallurgical industry to convert the chromite to chromium alloys or additives.

Chromium's major use is as an alloying ingredient in steel making to produce stainless steel. Stainless steel has increased resistance to oxidation and corrosion and is indispensible in many applications. It is also used to produce other steel alloys with increased shock resistance. Another chromium application is the plating of metals. End uses of chromium (usually steel alloys or stainless steel) include commercial and military aircraft engines, marine turbines, machine tools, and many other fabricated metal products.

Supply. The majority of chromium must be imported. The Republic of South Africa, the Soviet Union, and Zimbabwe (Rhodesia) are the leading suppliers to the U.S. Domestic production of chromium consists entirely of that which is recycled from scrap. Up to 9% of demand in recent years has been satisfied in this manner.

World resources of chromium are more than ample to meet demand for many centuries, but 99% of these resources are concentrated in southern Africa. The U.S. has limited deposits (mainly in Montana and Oregon), but mining of these resources in the near future is unlikely due to economic and environmental constraints.

Demand. Chromium consumption in the U.S. is expected to grow at an average annual growth rate of 3.2% through the year 2000. Demand for chromium is a function of investment in machinery and equipment and the economic cycles of the transportation and construction industries. World demand is expected to grow at a rate comparable to that in the U.S. for the next 20 years.

The U.S. consumption trend for chromium from 1965 to 1980 is shown in Figure A-2.

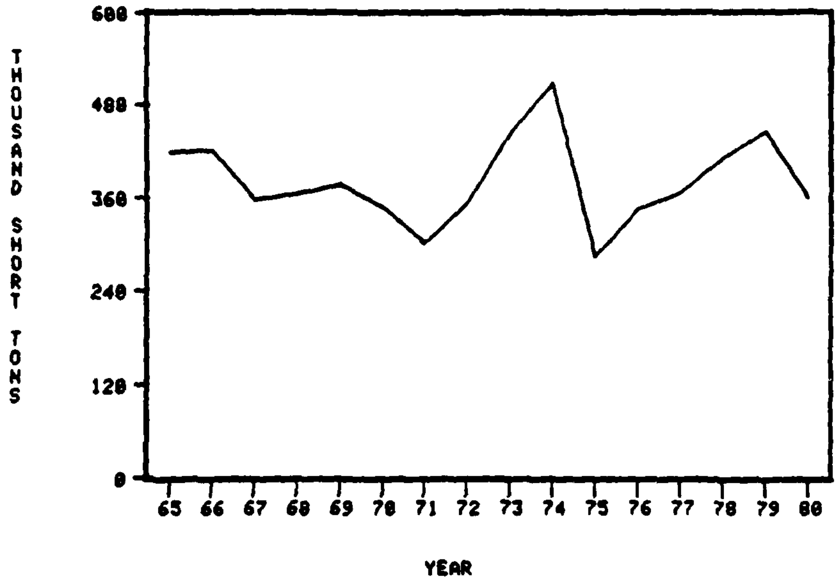

Figure A-2. Chromium Consumption.

<u>Substitutes</u>. For various metallurgical purposes chromium may be replaced by nickel, cobalt, columbium, molybdenum, or titanium, but cost is generally greater and performance may be degraded. For decorative trim, chromium is being replaced by aluminum or plastics.

There is no known substitute for chromium in stainless steel; the substitution path here must be to substitute materials for the stainless steel where possible.

COBALT (Refs. 4, 6)

Description and Uses. Cobalt is a silvery gray metal usually mined as a byproduct of nickel and copper. Generally, the ores mined have a small percentage of cobalt and must be concentrated prior to processing.

Cobalt has characteristics that impart improved strength and heat resistance to other metals when alloyed. This property makes it a very important metal for use in aircraft engines. Besides this major use, cobalt has excellent magnetic properties that make it valuable in many electrical applications such as motors and loudspeakers. Cobalt is also an important metal in high strength tools and drilling bits.

Supply. The U.S. relies almost totally on imports for its supply of cobalt, with the remainder (6%) supplied from domestic recycling activities. Zambia and Zaire are the world's largest producers of cobalt and our largest sources of supply.

World resources are more than adequate to meet estimated demand through the year 2000, but production of cobalt is totally dependent on copper and nickel mining activities. Due to demand fluctuations of these two metals, periodic shortages of cobalt might occur.

Although there has been no domestic production of cobalt in recent years, continually higher prices might signal the resumption of mining. There are many deposits of cobalt in the U.S., the richest being those in Idaho and Missouri. Another potential source of supply (although not for some years) is from cobalt-bearing manganese nodules on the ocean floor.

Demand. Domestic demand for cobalt is projected to increase at an annual rate of 3.5% through the year 2000. A slightly higher rate is forecast for world-wide demand. Major components of demand include aircraft production, the rising use of cobalt superalloys, and the expansion of the electrical industry in many parts of the world. Another major development that could

affect cobalt demand is the possibility of using cobalt in batteries for electric vehicles.

The U.S. consumption trend for cobalt from 1965 to 1980 is shown in Figure A-3.

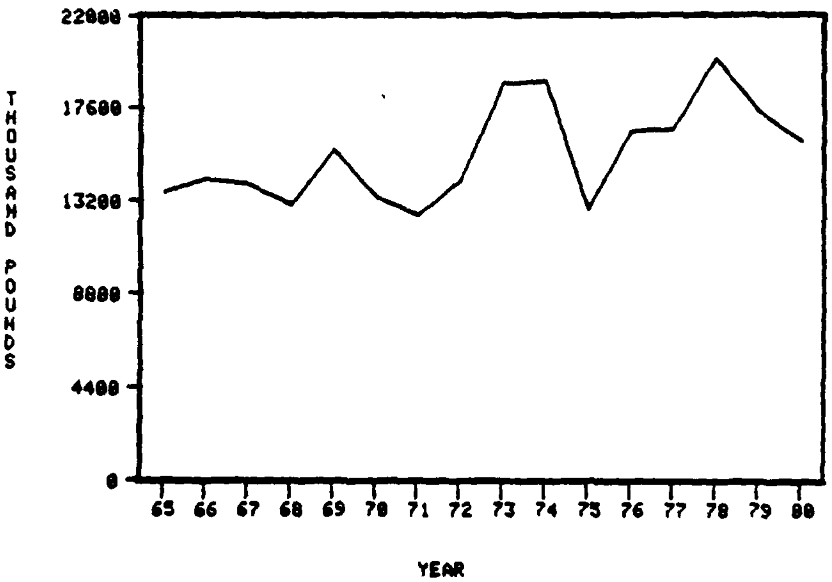

Figure A-3. Cobalt Consumption.

<u>Substitutes</u>. Ferrite magnets can be substituted for those made of Alnico (aluminum-nickel-cobalt). Nickel may be substituted in some superalloy applications, but at the expense of performance. Reducing the amount of cobalt used in superalloys, rather than substitution, can stretch supply in times of scarcity.

COLUMBIUM (Refs. 5, 7)

Description and Uses. Columbium is an element normally found as a raw material in the form of heat-fused ore and mineral concentrates. Its principal use is as an ingredient in specialty steels, including high strength, low alloy types. When used in stainless steel, columbium improves corrosion resistance; in carbon steel, small amounts of columbium produce an increase in yield strength and toughness. Another important application is in nickel- and cobalt-based superalloys for use in jet engine parts.

Supply. There is currently no domestic mining of columbium. The largest producers upon whom we depend are Brazil and Nigeria. Economically extractable world reserves are adequate to meet demand through the year 2000 and beyond. Relatively low grade domestic resources could produce enough columbium to meet U.S. demand given sufficient lead time and substantial price increase.

Demand. U.S. as well as world demand is expected to increase at an average annual rate of 6.1% through the year 2000. Further increases in demand will depend on possible use of columbium in fusion reactors and on possible substitution of columbium in superalloys due to shortages of other materials.

Substitutes. Vanadium and molybdenum can be substituted for columbium in high strength steels. In superalloys, titanium can be substituted.

Recycling. Recycling of columbium is insignificant.

COPPER (Refs. 4, 5, 7)

Description and Uses. Copper is a reddish-brown malleable, ductile metal and an excellent conductor of heat and electricity. It is generally mined in open pits and smelted to purity.

The majority of copper is used for electrical wire. Another principal application is in construction, especially piping. When alloyed with other metals, copper is used to form bronze and brass.

Supply. The U.S. is the world's largest producer of copper; however, it still relies on import for roughly 14% of its needs. These imports are supplied by Canada, Chile, Mexico, Zambia, and other countries. Domestic production is located chiefly in the western states of Arizona, Utah, New Mexico, and Nevada.

Close to one-third of the copper consumed in the U.S. is supplied by the recycling of both new and old scrap. World resources of copper are very large and ample to meet future demand, with a substantial amount contained within the U.S. Deep sea nodules represent an additional source of copper that could be exploited in the future.

Demand. Demand for copper is cyclical and parallels activity in the electrical industry. Future demand is expected to follow the same pattern although overall consumption will depend on the price of copper with respect to competing materials. This fact is evidenced by the recent move away from all copper plumbing in home building.

The U.S. consumption trend for copper from 1965 to 1980 is shown in Figure A-4.

Substitutes. For electrical purposes, aluminum can be substituted for copper. In plumbing, pipes can be made of plastics.

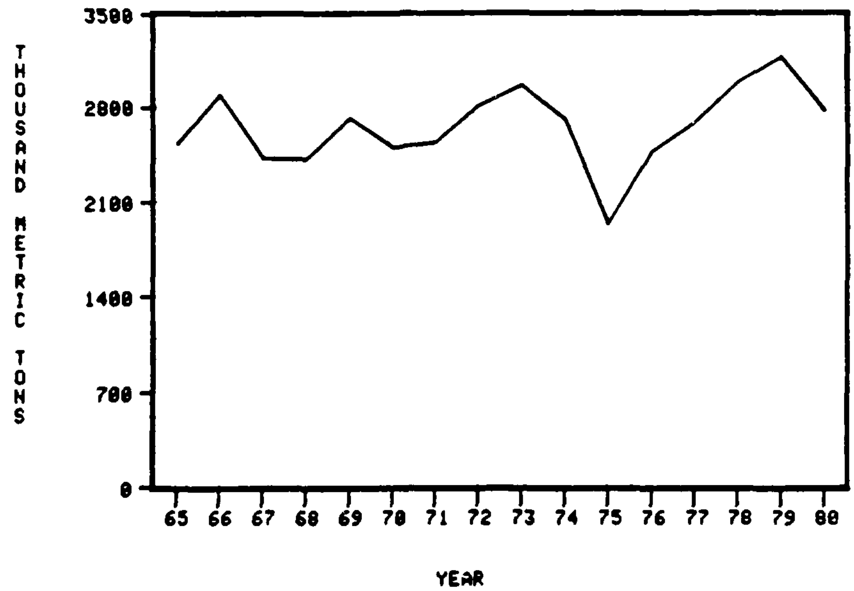

Figure A-4. Copper Consumption.

AD-A113 459 DOTY ASSOCIATES INC ROCKVILLE MD F/G 15/5
STUDY OF INCREASING LEAD TIMES IN MAJOR WEAPON SYSTEMS ACQUISIT--ETC(U)
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UNCLASSIFIED DAI-TR-254 NL

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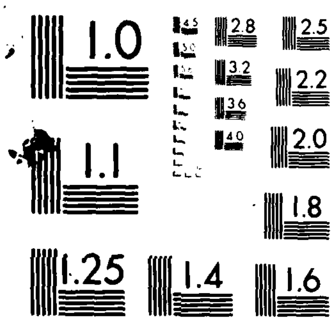

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

MAGNESIUM (Refs. 5, 6)

Description and Uses. Magnesium is the eighth most abundant element in the earth and also the third most prevalent element dissolved in seawater. When processed from either source, magnesium forms useful compounds, as well as a strong light-weight metal. Metal processing uses an electrolytic process similar to that used in aluminum production.

As a metal, magnesium is used extensively in aluminum alloys to increase strength and improve corrosion resistance in marine applications. Magnesium alloy metals are used in aircraft, missiles, and machinery. It is also used as a thermal insulator for boilers and pipes. In compound forms, magnesium is used as a heat resistant furnace lining in the steelmaking process.

Supply. The U.S. is, and is likely to continue to be, a net exporter of magnesium. For the past three years, exports have amounted to nearly 30% of domestic production. Resources of magnesium, particularly those obtained from seawater, are inexhaustible both domestically and world wide.

Demand. Demand for magnesium metal is a function of continued increasing usage in transportation equipment and machinery. Most probable estimates indicate that consumption will triple over the next 20 years. This estimate depends on the extent to which magnesium will be used in place of other competing metals and manmade materials. Refractory use of magnesium compounds is expected to increase at a lower rate than magnesium metal.

Substitutes. Aluminum and zinc can be substituted for magnesium in some casting applications. In refractory use aluminum, zirconia, and chromite may be used.

Recycling. Recycling from old scrap accounts for about 13% of U.S. supply of magnesium.

MANGANESE (Refs. 4, 5, 6)

Description and Uses. Manganese is a gray-white metallic element which is essential in modern steelmaking. All steels use manganese in processing (where it removes oxygen from molten metal) and some in alloying (where manganese improves steel's hardness and strength). Manganese also imparts strength, hardness, and corrosion resistance to aluminum and magnesium. A minor, although important, use of manganese is as a depolarizer in dry-cell batteries.

Supply. Domestic supply of manganese (from low grade ores) satisfies only 2% of U.S. consumption. Major countries on which we depend include the Republic of South Africa, Gabon, and Brazil.

Identified world reserves, located principally in the Republic of South Africa and the Soviet Union, are more than adequate to meet expected future demand through the year 2000. U.S. deposits are not expected to be exploited due to their low grade unless future technology makes it feasible. An extensive potential future source of manganese is seabed nodules.

Demand. Demand for manganese is tied directly to steel usage. Using this fact, U.S. demand is expected to increase at an annual rate of 1.4%, and world demand at 2.9% for the next twenty years. It is not likely that new steel-making techniques will significantly affect demand for manganese.

The U.S. consumption trend for manganese from 1965 to 1980 is shown in Figure A-5.

Substitutes. There is no satisfactory substitute for manganese in steel-making.

Recycling. There is no significant recycling of manganese.

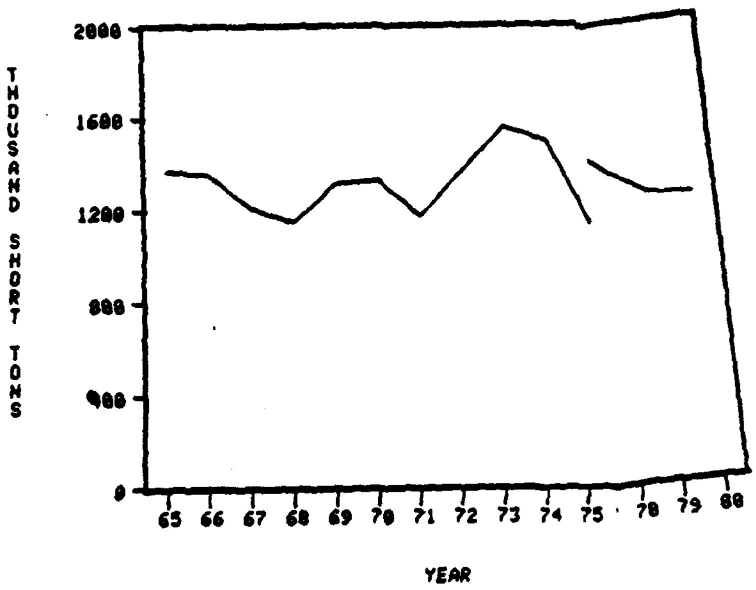

Figure A-5. Manganese Consumon.

MICA (Refs. 3, 5)

Description and Uses. Mica is a group name for a number of complex silicate minerals, including muscovite and phlogopite. These two types are commonly referred to as sheet mica, occurring naturally as tough, flexible sheets. These sheets are mined, split, and trimmed, all by hand, in a time consuming process.

When punched or stamped into specific shapes, sheet mica is very useful in electrical and thermal insulating applications. Because mica can be cut to very fine tolerances, it is used in capacitors and vacuum tubes. Other end uses include washers in computer equipment, electrical insulators in motors and generators, and retardation plates in lasers.

Supply. The U.S. is totally dependent on imports for its supply of sheet mica, principally from India. Brazil and Madagascar also supply some sheet mica. While some reserves of sheet mica lie within the U.S., they are uneconomical due to tremendous labor costs. Large deposits of mica bearing rock exist in India and Brazil. Because of the sporadic occurrence of sheets, the supply of this form of mica cannot be estimated.

Demand. Due mainly to increasing substitution by other materials, demand for sheet mica is decreasing at a rate of 6% per year. This trend is expected to continue through the year 2000. Another factor in the downward trend is decreased demand for vacuum tubes.

Substitutes. Substitutes for sheet mica include alumina ceramics, glass, polystyrene, silicon, teflon, and nylon. A process to produce large crystals of synthetic mica has not yet been developed.

Recycling. There is no recycling of sheet mica.

MOLYBDENUM (Refs. 4, 5, 6)

Description and Uses. Molybdenum is a silver-white metal with a very high melting point, high strength, and good corrosion resistance. The element is usually found in compound form with silicon, which is mined and then concentrated to a pure form. A limited amount of molybdenum is also obtained as a by-product of copper mining. Molybdenum's major use is as an alloying ingredient in steelmaking where it imparts improved hardenability and increased strength, especially at high temperatures. It is also used in stainless steels to give added corrosion resistance. These types of steels find end uses in nearly all major industry segments including transportation equipment, industrial machinery, oil production, and military armament. Nickel- and cobalt-based superalloys also use molybdenum and are employed in the manufacture of jet aircraft and missiles.

Supply. The U.S. is responsible for over 60% of world output of molybdenum and exports half of its production. Other producing countries include Canada, Chile, and the Soviet Union. Most of the reserves of molybdenum occur in concentrated deposits in the western mountain regions of North and South America. With over half of these reserves located in the U.S., domestic supply is more than adequate to meet demand through the foreseeable future.

Demand. Domestic consumption of molybdenum in the U.S. is expected to increase at an average annual growth rate of 4.2% through the year 2000. This forecast is based on projected growth in industries that use molybdenum, and on the assumption of increasing applications for molybdenum as an alloying element in specialty steels. World-wide demand should increase at a slightly higher rate due to faster rates of growth in developing countries.

The U.S. consumption trend for molybdenum from 1965 to 1980 is shown in Figure A-6.

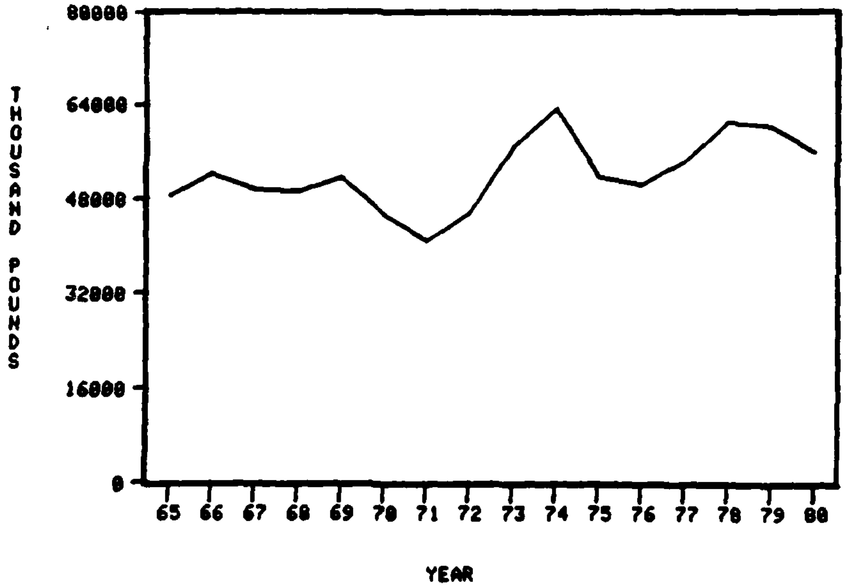

Figure A-6. Molybdenum Consumption.

Substitutes. Possible alternatives do exist for substitution of molybdenum in most applications, but they have not been used due to the metal's availability and relatively low price. As an alloying ingredient, columbium, chromium, nickel, and vanadium can be used to obtain desired effects. Also, tungsten can replace molybdenum in high speed applications such as machine tools.

NICKEL (Refs. 4, 6)

Description and Uses. Nickel is a metal that is vital to modern construction and industry. Nickel's resistance to corrosion and the ability to impart strength and corrosion resistance to alloys leads to its extensive use.

As an important ingredient in stainless steels, nickel increases corrosion resistance. One use of such steel is as sheet metal structural members in aircraft. In other steel alloys, especially the case-hardened varieties, nickel improves wear resistance and minimizes cracking. Typical uses for this type of steel include crankshafts, axles, landing gear components, and missile parts. Nickel-copper alloys have excellent strength and corrosion resistance in water and are therefore used in propellers, shafts, and other marine applications. Specialty nickel-base alloys that resist stress and corrosion at high temperatures (known as superalloys) are very valuable components of jet engines.

Supply. Sixty to seventy percent of U.S. nickel consumption is supplied by imports, chiefly from Canada and New Caledonia. Of the remaining percentage, 10% is met through domestic production of nickel, and the rest through recycling of scrap.

World reserves of nickel are forecasted to be adequate to meet future demand. Major deposits are located in Canada and New Caledonia. Domestic resources are contained mainly in Oregon and California. Many of these deposits are currently subeconomic but could be mined to increase domestic production if future conditions make it feasible. A future source of nickel from sea bed manganese nodules has significant potential to increase U.S. supply.

Demand. Since much of nickel is consumed in capital goods and consumer durables, demand is sensitive to general economic cycles. In the long run, domestic nickel demand should increase at an average annual rate of 3.7% through the year 2000. Rest of the world demand should experience a slightly

higher rate. Extensive use of electric vehicles using zinc-nickel batteries could cause an additional increase in demand.

The U.S. consumption trend for nickel from 1965 to 1980 is shown in Figure A-7.

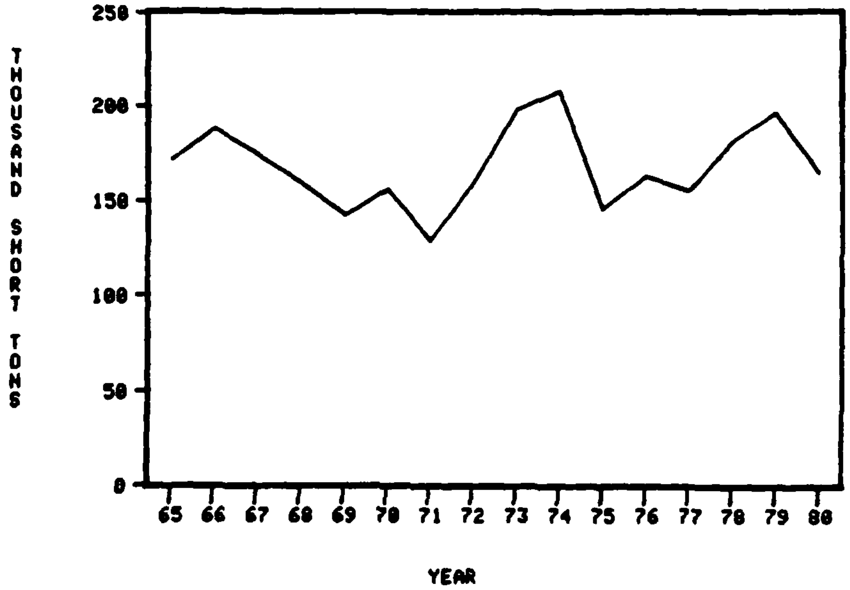

Figure A-7. Nickel Consumption.

Substitutes. Stainless steels containing chromium, manganese, and relatively little nickel can be used in place of those with higher nickel content.

Nickel-base superalloys can be substituted with cobalt-base or columbium-base metals. In addition, carbon steel clad with titanium can be used in applications requiring high strength and corrosion resistance.

PLATINUM (Refs. 4, 5, 6)

Description and Uses. The platinum group metals (platinum, palladium, rhodium, ruthenium, iridium, and osmium) occur together in nature and are among the scarcest of metallic elements. They are associated with nickel and copper in most deposits and with gold in others. Major properties of the platinum metals include chemical inertness and excellent catalytic activity.

In automobiles, platinum is used in the catalytic converter to reduce emissions. In the chemical industry, the metals are used as catalysts in the manufacture of many chemicals including nitric acid. Platinum's use as a catalyst is also valuable in petroleum refining. Applications that take advantage of the group's inertness and thermal stability include telephone relays, electron tubes, printed circuits, and resistors. Platinum is also used in dentistry and for jewelry.

Supply. A small amount of platinum (less than 1% of domestic demand) is supplied by U.S. production. Major efforts are undertaken to recycle platinum due to its high price, and 13% of consumption is supplied by this means. The remaining amount is supplied by imports, principally from the Republic of South Africa and the Soviet Union.

U.S. resources of platinum metals, located in Montana, Minnesota, and Alaska, are sizeable but are not currently economically feasible. Proven reserves in the Republic of South Africa are by far the largest in the world and are adequate to meet future demand through the year 2000.

Demand. Demand for platinum group metals is expected to increase at an average annual rate of 2.5% for the next twenty years. Lower priced substitutes are continually being sought and their success will have a great impact on demand. Also influencing demand is the expected phase-out of catalytic converters in automobiles and the increased use of solid state relay devices. On the plus side, jewelry use and hoarding of precious metals will add to consumption.

The U.S. consumption trend for platinum from 1965 to 1980 is shown in Figure A-8.

Substitutes. In electronic applications, gold, silver, and tungsten can be used in place of platinum metals. Vanadium and titanium can be substituted in some catalytic uses.

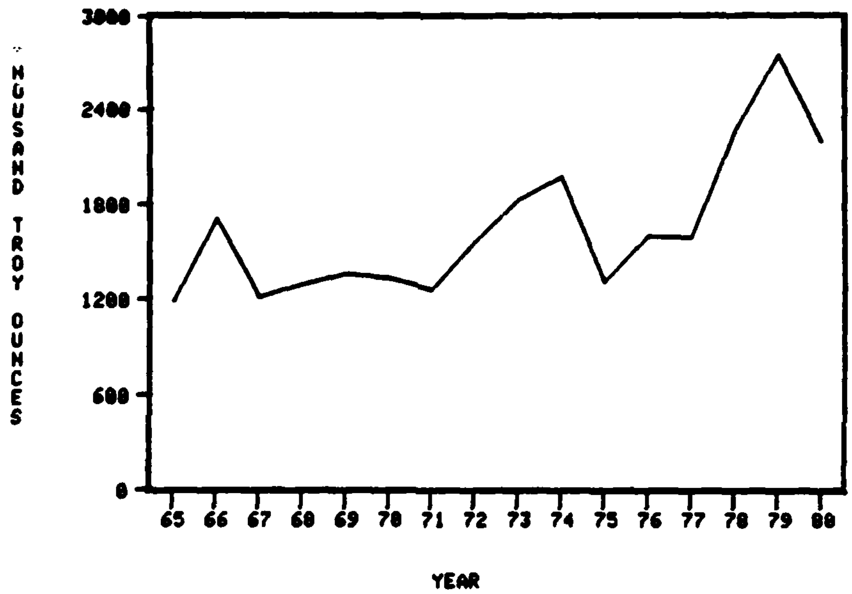

Figure A.8. Platinum Consumption.

TANTALUM (Refs. 5, 6)

Description and Uses. Tantalum is a relatively rare, corrosion-resistant, ductile metal with a high melting point. The two major sources of tantalum are tantalum-bearing ores and slags produced from tin smelting. Both raw materials also usually contain significant amounts of columbium.

When produced as tantalum oxide, the material has superior dielectric properties and is chemically inert, making it valuable in the manufacture of high reliability electronic components, particularly capacitors. When tantalum is combined with other metals such as cobalt and nickel, superalloys can be produced for applications in jet engines and gas turbines.

Supply. There is currently no domestic mining of tantalum, but processing is performed on imported ores and slags. In an emergency situation, or if tantalum prices increase enough, U.S. deposits -- particularly those in Idaho -- could be recovered. Major exporting nations include Thailand, Canada, and Malaysia.

World resources of tantalum are adequate to meet future demand through the year 2000, but unless more economic recovery is possible, prices will rise. A good portion of tantalum supply depends on tin mining and smelting, which is expected to increase at a much lower rate than tantalum demand. This projection may result in further increases in the price of tantalum in order to keep up production.

Demand. Demand for tantalum is expected to grow at an annual rate of 4.1% through the year 2000, based on the assumption of limited supply and increasing prices. Increasing demand for electrical components will be offset somewhat by technological improvements requiring less tantalum per unit. Due to high prices, demand for tantalum in superalloys is expected to be satisfied by other metals.

Substitutes. Aluminum or ceramics can be substituted for tantalum in capacitors, especially in less demanding applications. In superalloys for

high temperature usage, columbium, molybdenum, tungsten, and platinum can be used.

<u>Recycling</u>. Recycling of old scrap presently supplies 3% of domestic consumption.

TITANIUM (Refs. 4, 5, 6)

Description and Uses. Titanium metal is produced from the raw material rutile, one of many titanium-bearing ores. Other ores are also used for processing titanium dioxide, a widely used white pigment. Use as a pigment accounts for 92% of titanium consumption. As a metal, titanium is strong, lightweight, and highly corrosion resistant. These properties make it an indispensable component in jet engines, airframes, missiles, and space applications. Titanium is also used as an alloying ingredient in high strength, low alloy steels, where it improves weldability.

Supply. With domestic producers running at near full capacity in recent years, imports of titanium metal were required to supply 10-15% of U.S. consumption. These imports came mainly from Japan and the Soviet Union. Rutile, used in the production of titanium, is almost totally imported, chiefly from Australia. U.S. production of this raw material is limited to one mine in Florida, and most of its output goes into the manufacture of pigment.

World resources of rutile are adequate to meet forecasted demand through the year 2000. Synthetic rutile, fabricated from ilmenite (another titanium-bearing ore) will also contribute to future supply. U.S. reserves of rutile and ilmenite are nearly sufficient to meet domestic demand to the year 2000, but imports will still be an important source due to land use and environmental laws.

Demand. Demand for titanium metal is directly related to economic indices for the aircraft industry and is expected to increase at an average annual rate of 5.5% through the next 20 years. This figure is based on industry plans to build a new generation of lighter, more fuel-efficient commercial airliners and on continued defense requirements for high performance military jets.

The U.S. consumption trend for titanium from 1965 to 1980 is shown in Figure A-9.

Substitutes. There is no presently available acceptable substitute for titanium in aircraft and space applications.

Recycling. An estimated 75% of ingot metal becomes scrap while being processed to finished parts. About one-third of such scrap is uncontaminated and returns to the ingot melt cycle. Recycling of old scrap is limited due to titanium's limited usage and long useful life (3-10 years in aircraft engines; over 20 years in airframes).

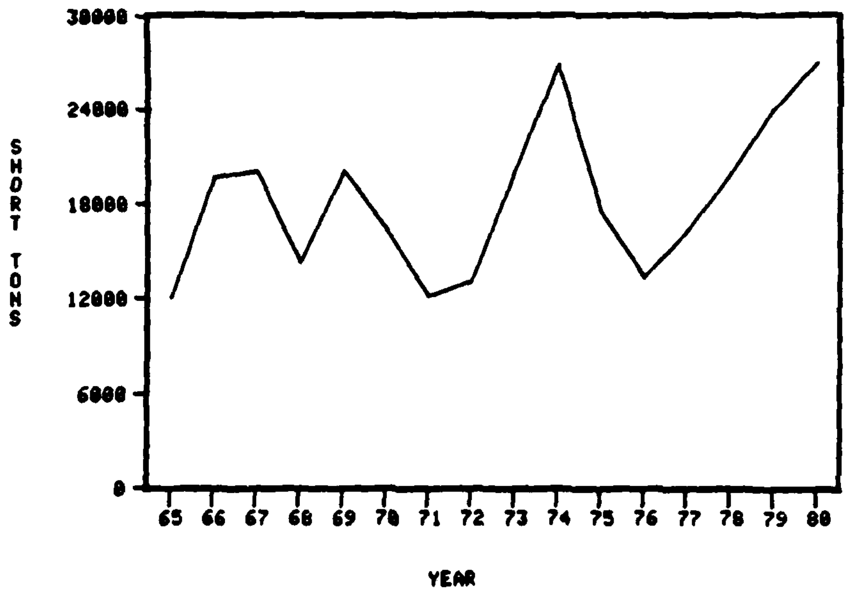

Figure A-9. Titanium Consumption.

TUNGSTEN (Refs. 4, 5, 6)

Description and Uses. Tungsten is a rare, heavy, silver-gray metal with a melting point higher than any other metal. Its other properties include high corrosion resistance, good thermal and electrical conductivity, and high strength at hot temperatures.

Tungsten's principal use is as tungsten carbide to make cutting edges of machine tools. It is also used as an alloying ingredient in specialty steels to improve high temperature strength and shock and corrosion resistance. Superalloys also take advantage of tungsten's high temperature properties for use in jet engines. Tungsten wire is used as the filament in light bulbs and disks made of tungsten are used in automotive distributor points.

Supply. Imported tungsten accounts for over 50% of domestic consumption. Major exporting countries on which the U.S. depends are Canada, Bolivia, and Thailand. The balance is made up through domestic production (less than 30% of supply) and recycling of scrap (17%). In recent years, sales from government stockpiles has also been a source of supply.

World resources of tungsten, especially those currently economically extractable, are limited. Over half of these resources are concentrated in mainland China with the remainder scattered around the earth. U.S. deposits are located principally in the western states of California, Colorado, and Nevada. Higher prices and/or new extraction technology is needed in order to meet expected demand through the year 2000. One possible advancement may come through the economic recovery of tungsten from brine lakes in California.

Demand. Demand for tungsten is expected to increase at an average annual growth rate of 4.5% in the U.S. for the next twenty years. This forecast is mainly based on the growth rates of the underlying industries that produce machine cutting tools. World-wide demand should rise at a slightly lower overall rate.

The U.S. consumption trend for tungsten from 1980 is shown in Figure A-10.

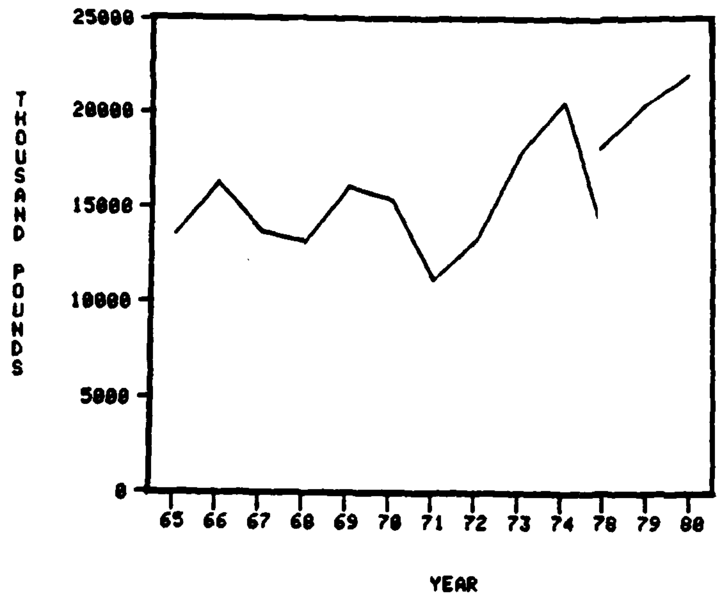

Figure A-10. Tungsten Cons

<u>Substitutes</u>. In some machine applications,n carbide, tantalum carbide, or columbium carbide can be substitutengsten carbide. No wholly satisfactory substitutes are known for tuntaining superalloys used in aerospace applications.

APPENDIX B

AN ASSESSMENT OF BEARINGS LONG LEAD TIME PROBLEMS

Bearings are an integral part of machinery that provide for free movement at the interface of moving parts. Virtually all mechanized equipment utilize bearings in one of many forms including ball bearings, tapered bearings, ring bearings, and roller bearings. While there are many standard shapes and sizes of bearings, many uses dictate the need for special metals and/or tolerances. The largest consumer of bearings is the automotive industry, absorbing 16 to 18 percent of output. Applications in aircraft account for about 4 percent of total bearing output (Ref. 1). Procurement by the Department of Defense consumes roughly one percent of output.

The bearing industry is very concentrated, with the 4 largest companies controlling over 50 percent of sales, and the 8 largest nearly three-fourths of sales. This situation is even more pronounced at segmented levels where, for instance, in tapered roller bearings, the 4 largest firms account for 90 percent of sales, and one firm controls about two-thirds of the segment (Ref. 2). Industry experts expect demand in most bearings market segments to triple by the end of the 1980s, but increases in capacity are not keeping pace to satisfy the demand. Low investment in new capital equipment is a problem throughout U.S. industry, and bearing manufacturers are no exception. A major impact on domestic bearings manufacturers' production and sales has been the proliferation of imported bearings (mostly standard small-sized ball bearings) in recent years. The loss of these markets now being served by imports cuts into the profit and capital formation of the domestic industry. Current strategy for most firms is to concentrate either in the replacement bearing market or in more specialized applications.

Lead times for bearings have been largely a function of demand versus capacity. In the 1974-1975 time frame, huge world-wide demand increases sent lead times much higher for nearly all types of bearings. Currently, lead time problems are being experienced in specialized precision bearings that are of

particular importance to military aircraft production. These bearings currently have lead times of over one year, due mainly to the following reasons:

- limited production capacity,
- tight tolerances imposed by Military-Specifications, and
- difficulty obtaining raw materials.

Limited Production Capacity

Capacity restrictions in the manufacture of specialty bearings, mainly for aircraft engines, has resulted in protracted lead times. The problem is particularly acute due to the increase of commercial aircraft production. Equipment to make bearings also has a lead time of one to two years, and firms are very cautious when expanding for a volatile market such as aircraft. A significant related problem in recent years was labor problems at two principal bearing companies. Strikes of 22 weeks and 15 weeks in 1979 caused large backlogs, the effects of which are still being felt.

Tight Tolerances Imposed by Military Specifications (MIL-SPECs)

Military Specifications require ultra-high precision and reliability for bearings used in aircraft. These bearings must be able to withstand high stress and temperature without failure. The time consuming process of quality control and extensive testing results in many bearings having to be ground three to four times, with many still being rejected and having to be remade.

The need for high precision also translates into the need for expensive machining equipment in which companies are not investing, and a decreasing number of qualified suppliers for the product that are interested enough to go to the extra effort needed to produce the MIL-SPEC bearings without increased monetary compensation.

Difficulties Obtaining Raw Material

Tungsten alloys, used in aircraft applications have been experiencing increased demand which may result in supply shortages for bearing manufacturers. The availability of bearing quality steel has been a slight problem, having eased recently due to the downturn in automobile production, but with the projected readjustment in the automotive industry, the availability situation may again deteriorate.

APPENDIX C

AN ASSESSMENT OF CASTINGS AND FORGINGS LONG LEAD TIME PROBLEMS

Casting and forging are the two most widely used techniques for forming metals from ingots or sheets into usable end products. Castings and forgings are necessary components for nearly all machinery as well as for some construction goods, and are essential in the manufacture of military systems such as aircraft, tanks, guns, missiles, ships, etc., in forming structural framework, valves, and turbine parts. Foundries produce castings through a technique of pouring molten metals (aluminum, steel alloys, etc.) into cavities of sand, metal, or ceramic molds created by skilled craftsmen. Depending on complexity, the making of molds, the pouring of the molten metals, and the subsequent machine finishing usually required are very time consuming, labor intensive operations.

Forging is a process in which pressure is applied mechanically to cool or heated metal to squeeze or bend it into the required shape. Different methods of forging include compression between dies, rolling, hammering, and pressing. Metals used in these applications are generally aluminum, titanium, and alloyed steels.

Overall statistical data on the casting and forging industries presents what would be expected from a heavy manufacturing capital goods industry segment -- a cyclical behavior that fluctuates with the overall economic expansion and contraction, and average growth rates that are comparable to general manufacturing indices (Ref. 1).

Lead time problems associated with DoD procurement of castings and forgings are predicated on many factors, including:

- Industrial capacity,
- Raw material availability,
- Competition from commercial sectors,

- Manpower/machinery shortages,
- OSHA/EPA regulations, and
- Military Specifications and testing requirements.

Industrial Capacity

High capacity utilization rates in the casting industry have prompted foundries to increase lead times for certain items. Particularly affected presently are high quality large castings made of specialty steels and aluminum, principally for use in aircraft manufacturing. At the same time, however, a great deal of over-capacity is currently being experienced by foundries oriented towards shipbuilding applications. A recent Navy Shipbuilding Scheduling Office (NAVSHIPSO) survey of shipbuilding support foundries indicated that the majority of these concerns could support Navy requirements 2 to 3 times over 1980 demand (Ref. 2). Underutilization is also a problem being experienced by foundries dependent on the automotive market. The disparity between these different sectors is indicative of the specialization and fragmentation of the industry, as well as the barriers to entry into more lucrative markets. The major barriers for the manufacture of aircraft castings are the level of expertise needed to work with superalloy metals and the higher quality product that is required.

Casting industry capacity has remained fairly constant during the last five years, despite the closing of nearly 200 foundries as a result of OSHA and EPA regulatory enforcement. This information points to the trend of consolidation by the industry towards larger plants. An increase in capacity necessitates extensive investment in capital equipment, but nonetheless industry experts expect a 15% increase in capacity by 1985.

The forging industry is currently running at 50-75% of capacity. Again, however, as with castings, lead times for large aircraft-quality forgings have increased substantially in the past two years. This problem is due primarily to the limited number of presses and hammers that are designed for aircraft work. The situation in shipbuilding reflects an extreme underutilization of capacity for forgers in much the same magnitude and for the same reasons as described for castings.

Aircraft forgers, who depend rather heavily on military procurement, are unwilling to invest in new capital equipment based on the cyclical nature of their business. Standard funding practices by DoD create uncertainty that dampens planning and also contributes to conservative, "better safe than sorry," expansion plans. In short, as prudent businessmen, forging executives will not invest today in a machine that will be idle tomorrow. The present situation is exacerbated by the boom in commercial aircraft production, but this increase is considered only temporary by industry experts. In fact, recent cutbacks by commercial aircraft producers have eased lead times considerably. As further evidence of the industry's reluctance to expand to meet temporary surges, at least two major forgers operate with only two work shifts, although they currently have enough work to keep them busy around the clock. Reasons for this include the high cost and long training period required when hiring new workers, and also the fact that a third shift would necessitate a much higher degree of maintenance.

Raw Material Availability

The time needed to obtain metal ingots or billets for processing can be the primary driving force behind an increase in lead time, particularly when critical metal or their alloys are involved. Capacity bottlenecks currently exist at the processor level for producing titanium metal sponge from rutile (see Appendix A, page A-28, for a further explanation of titanium processing). This limited capacity, compounded with a surge in demand for equipment requiring titanium, has resulted in allocation and increased lead times. Major titanium producers are presently increasing capacity and hope to quickly increase output, and some improvement is expected by the middle to end of 1981 (Ref. 3).

Superalloys requiring cobalt, columbium, molybdenum, tantalum, and other metals are currently in periodic short supply due to import conditions and metalmaker's operations. For example, another shortage of cobalt, as occurred in 1978, could have the potential of seriously impacting availability of many superalloys. Continuing power shortages in the Pacific Northwest, compounded by increasing demand, may result in shortages of aluminum in coming years and could increase lead times for aluminum castings and forgings.

Competition From Commercial Sectors

Increases in demand from commercial users of castings and forgings have a profound effect on lead times, as evidenced recently in the aircraft sector. To the extent that owners of foundries and forge shops are unwilling, or unable, to expand to meet temporary demand schedules, a large increase in demand will strain capacity and stretch lead times.

Manpower/Machinery Shortages

Skilled craftsmen in the forging and casting industries are and have been in short supply. In particular, experienced hammer press operators and die makers are a problem. Although employing some automated equipment and measurement controls, casting is still as much an art as a science, and requires the services of highly skilled personnel to control the purity of the metal and the melting/cooling process. For higher quality castings, such expertise is critical. Attracting and retaining personnel has been one of the major problems for foundries in recent years. There is also a shortage of the highly skilled machinists who are needed to finish a piece to exacting tolerances.

Capital investment in the casting and forging industries, as in the American economy in general, is negatively affected by present taxation and depreciation policies, as well as high interest rates. Foundry equipment manufacturers, however, expect continued modest growth through 1985, and report order backlogs of close to one year. Forging press makers are currently experiencing an 18 month lead time for delivery (Ref. 4).

OSHA/EPA Regulations

Working condition improvements and clean air requirements as mandated by federal regulations of OSHA and EPA have been cited as the major cause of the closing of over 400 small foundries in the 1970s. Investment in equipment to meet these standards proved too onerous for many firms with limited financial resources. Many of these now defunct foundries were important to the military in that they were willing and able to do small batch specialty castings (Ref.

5). Forced investment in nonproductive equipment to meet federal requirements compounds the problem of low capital investment in the forging and casting industries and aggravates capacity problems. For example, money had to be spent by forgers in compliance with noise and vibration standards by OSHA and high cost anti-pollution devices were installed in foundries as required by the Clean Air Act.

Military Specifications and Testing Requirements

Aerospace products in general, and military specification items in particular, require extremely close tolerances and high standards. Since most cast and forged aircraft part must withstand heavy stress and/or high temperatures without failure, extensive testing is required. Additionally, pieces must be worked and reworked to meet the tolerances specified. In aircraft forgings, though, the tighter specifications and increased testing required by the government is a contributor, but not a major driver in the current lead time problem. In castings, most military requirements are for special and/or intricate shapes with rigid specifications. This type of product requires a double learning curve experience -- one to make the mold and the second to make the actual casting. Adding to the time requirement is the necessity inherent in casting to often rework or remold the casting due to flaws.

In summary, lead times for military castings and forgings are a function of specialized capacity versus demand, and the availability of raw material inputs. Bottlenecks exist where surges in commercial demand compete with defense procurement for the same class of product and can be aggravated by shortages of critical metals.

APPENDIX D

AN ASSESSMENT OF INTEGRATED CIRCUITS (I/Cs) LONG LEAD TIME PROBLEMS

Integrated circuits are the vital building block of modern sophisticated electronic equipment. In defense applications, these electronics have played an ever-increasing role in the U.S. defense posture. Today, nearly all major defense systems, including aircraft, ships, and missiles, depend heavily on electronics and integrated circuits. It is currently estimated that defense electronics account for one-third of major weapon system procurement costs (Ref. 1).

The integrated circuit industry's growth has been explosive, paced by rapidly advancing technology and decreasing unit costs. The industry began with the military as its first and largest user. In 1955, defense consumption of I/Cs comprised 38% of total demand; but as a result of the growth in commercial industry, the defense figure is currently down to 7%, and even with the increased sophistication of military hardware is expected to decrease further (Ref. 2). Consequently, industry dependence on defense business is minor and attitudes are accordingly reflected in responsiveness to military requirements.

Lead times for integrated circuits are virtually a direct result of supply/demand relationships. For instance, the first big jump in lead times occurred in 1974-1975 (see Appendix E, Figure E.1-56), a period over which demand for I/Cs more than doubled (Ref. 3). Compounding the problem for the military in times of high demand is the extra testing that MIL-SPEC items require.

Current factors associated with long lead times for military I/Cs, as identified by both military and industry experts, include:

- increased testing requirements,
- commercial competition, and
- peak capacity.

The high reliability requirements of defense electronics imposes a need for thorough and extensive testing of the integrated circuits that have become increasingly complex and miniturized over the past several years. The production and testing processes take time and require highly specialized equipment and trained personnel. Additionally, design modification during development and production can cause significant impacts on lead times.

Higher profits from less rigorous commercial applications are luring many I/C manufacturers away from producing defense items. A report issued from Air Force Systems Command in March 1980 cited many examples of this practice in aircraft avionics (Ref. 4). Increasing demand from private sectors of the economy including the aircraft and automotive industries, and the dynamic expansion in consumer entertainment devices have been largely responsible for this trend. Reasons cited for disinterest in defense business are typical of business sentiment in general:

- Government work requiring a disproportionate share of the manufacturer's limited skills and facilities due to high level process controls and testing,
- more certainty available thorugh multi-year, large volume commercial orders,
- vicissitudes of government business; small order quantities,
- low profitability compared to commercial work, and
- Government paperwork requirements.

Joint Army Navy (JAN) integrated circuits must be assembled and tested in the United States. This requirement is resulting in a limited number of qualified vendors as manufacturers are currently interested in overseas assembly and testing operations due to lower costs. The shrinkage in qualified vendors has strained domestic capacity and thereby increased lead times for this area. A more pervasive constraint on the capacity of the I/C industry is the increasing shortage of electronic engineers and circuit designers.

Increased demand from the commercial aircraft sector has recently created an acute problem for military program managers. Private users compete for

avionics equipment and aggravate the lead time situation. However, as cutbacks in commercial aircraft orders have occurred during the past six months, responsiveness to military requirements has increased. For example, the lead time for a commonly used MIL-SPEC integrated circuit (#883B), which was 40 weeks for most of 1980, is now only 20 weeks, due to the slackening of commercial orders (Ref. 5).

While the industry's reluctance to perform defense work is predicated on the reasons cited above, government expenditures have provided I/C firms with compensating benefits. Most importantly, defense acquisitions have tended to push the state-of-the-art, resulting in more highly accelerated technological progress than would have occurred through normal commercial requirements. Although the unique first-user role of the military in the 1950s does not exist today, research and development for demanding defense applications does tend to have advantageous commercial spillover in terms of new products and processes. This technology diffusion is occurring currently with the development of very large scale integrated circuits and very high speed integrated circuits (Ref. 3).

APPENDIX E

INCREASING LONG LEAD TIME ITEM TRENDS

This appendix contains 124 trend charts of items identified as having significantly increasing long lead times during the past several years. The acquisition and sources of the data are discussed in Appendix F, Study Objectives and Research Methodology. Although data was obtained from numerous sources, the largest amount of data analyzed by this study was obtained from the following commands and activities:

- Joint Aeronautical Materials Activity (JAMAC), Wright-Patterson Air Force Base, Ohio
- Materiel Development and Readiness Command (DARCOM) Headquarters, U.S. Army, Alexandria, Virginia
- Navy Shipbuilding Scheduling Office (NAVSHIPSO), Philadelphia Naval Shipyard, Philadelphia, Pennsylvania

For reference convenience, and as a result of the study data analyses, the trend charts have been divided into two distinct groups: Tab E.1 - Aerospace Long Lead Items, and Tab E.2 - Shipbuilding Long Lead Items. Had trend charts been developed for armored vehicles, they would have, on the average, reflected slightly longer lead times than those for shipbuilding.

There are 76 aerospace item trend charts and 48 shipbuilding item trend charts as indexed below. With reference to the charts, it is advised that in cases where data was not available for the intervening years between two established data points, a dashed line was used to connect the points but does not indicate the actual trend that occurred for a given time period.

Trend Chart	Figure	Page
Tab E.2 - Shipbuilding Long Lead Items		
Processed Material		
Aluminum Alloys, Plate, Heat-Treatable	E.2-1	E.2-3
Aluminum Alloys, Shapes, Extruded, Special or Complex Sections	E.2-2	E.2-3
Aluminum Alloys, Tubing, Round, Drawn, Above 6.0" Outer Diameter	E.2-3	E.2-3
Nickel Alloys, Pipe, Cold Drawn, 6.625" Outer Diameter and Above	E.2-4	E.2-4
Nickel Alloys, Tubing, Cold Drawn, 5.0" Outer Diameter and Above	E.2-5	E.2-4
Steel-Carbon, Pipe & Tubing, Seamless	E.2-6	E.2-4
Steel-Carbon, Pipe & Tubing, Welded	E.2-7	E.2-4
Bearings		
Bearing, Propulsion Shafting, Stern Tube & Strut, 6" to 15" Diameter	E.2-8	E.2-5
Bearing, Propulsion Shafting, Stern Tube & Strut, 16" to 36" Diameter	E.2-9	E.2-5
Bearing, Thrust, Main, Separately Mounted, 5" to 22" Diameter	E.2-10	E.2-5
Bearing, Thrust, Main, Separately Mounted, 23" to 33" Diameter	E.2-11	E.2-5
Bearing, Thrust, Main, Separately Mounted, 34" to 45" Diameter	E.2-12	E.2-6
Bearing, Thrust, Main, Separately Mounted, 45" to 60" Diameter	E.2-13	E.2-6
Bearing, Propulsion Shafting, Stern Tube & Strut, 6" to 15" Diameter	E.2-14	E.2-6
Bearing, Propulsion Shafting, Stern Tube & Strut, Above 15" Diameter	E.2-15	E.2-6
Castings		
Castings, Aluminum, Large	E.2-16	E.2-7
Castings, Aluminum Alloy, Permanent Mold	E.2-17	E.2-7
Castings (Sand), Steel Alloy, Small or Simple Shapes	E.2-18	E.2-7
Castings (Sand), Steel Alloy, Submarine Quality	E.2-19	E.2-7
Castings, Stern	E.2-20	E.2-8

Tab E.1 - Aerospace Long Lead Items

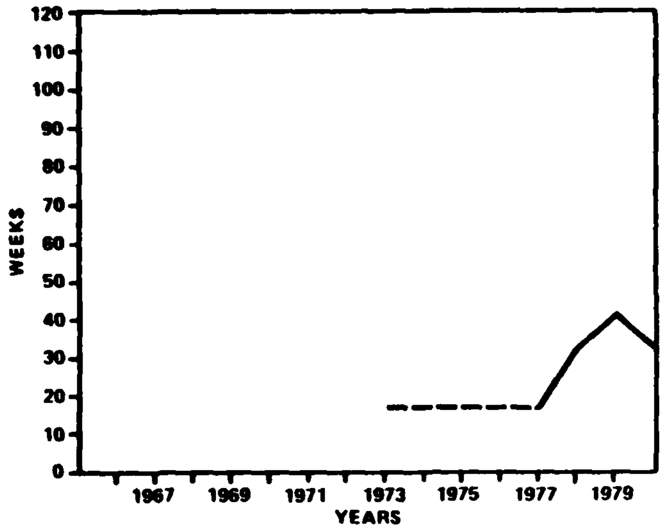

Figure E.1-1. Aluminum, Bar.

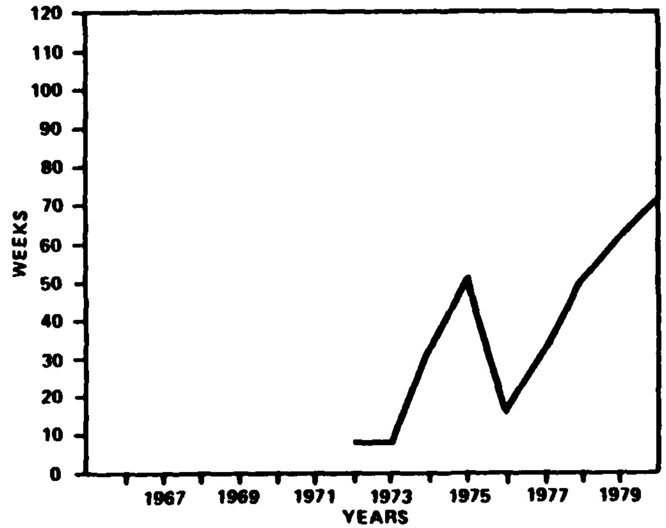

Figure E.1-2. Aluminum, Extrusion, Light.

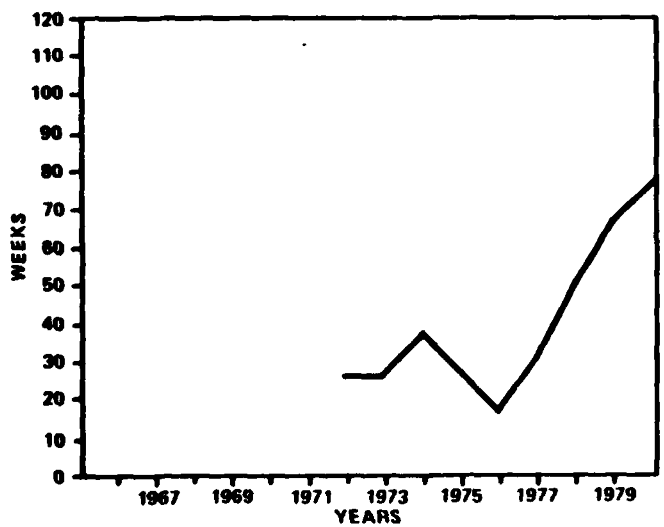

Figure E.1-3. Aluminum, Extrusion, Heavy.

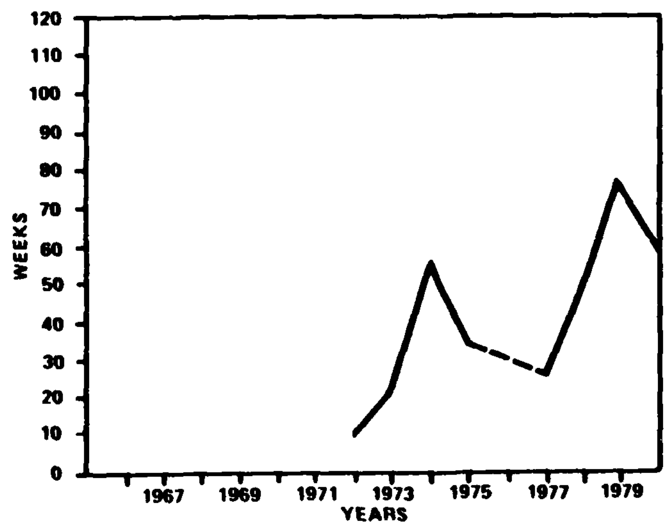

Figure E.1-4. Aluminum, Plate.

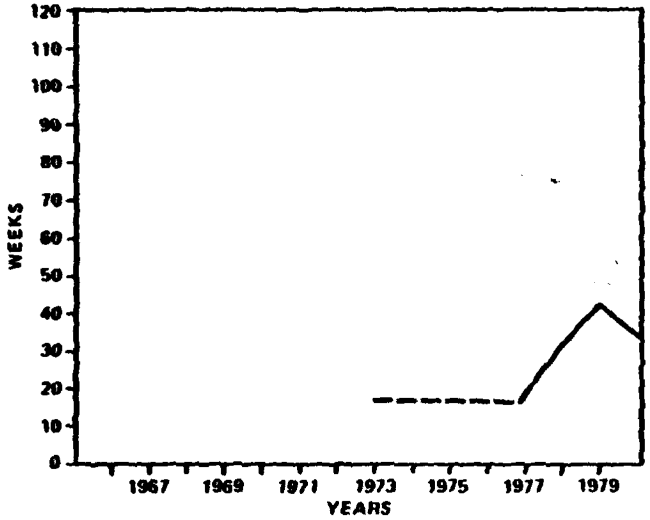

Figure E.1-5. Aluminum, Rod.

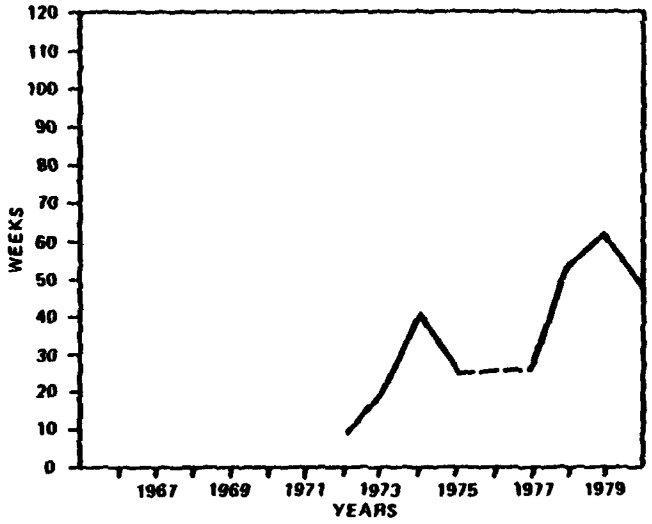

Figure E.1-6. Aluminum, Sheet.

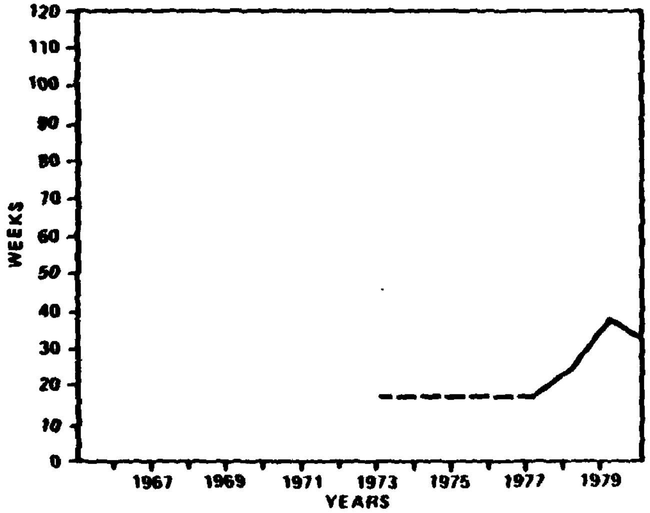

Figure E.1-7. Aluminum, Tubing.

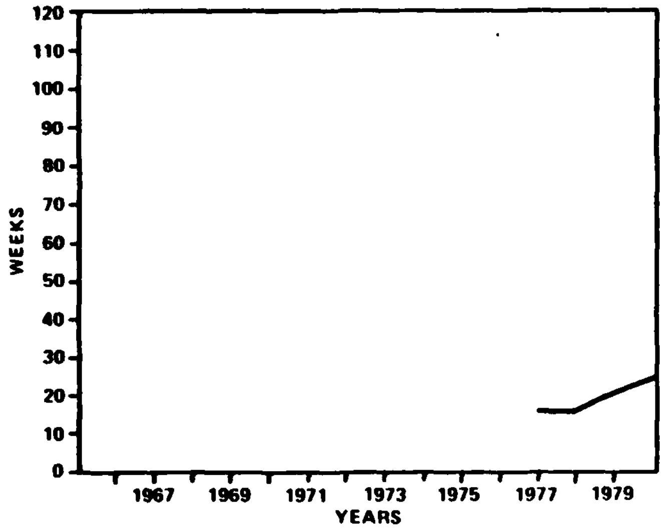

Figure E.1-8. Magnesium, Bar.

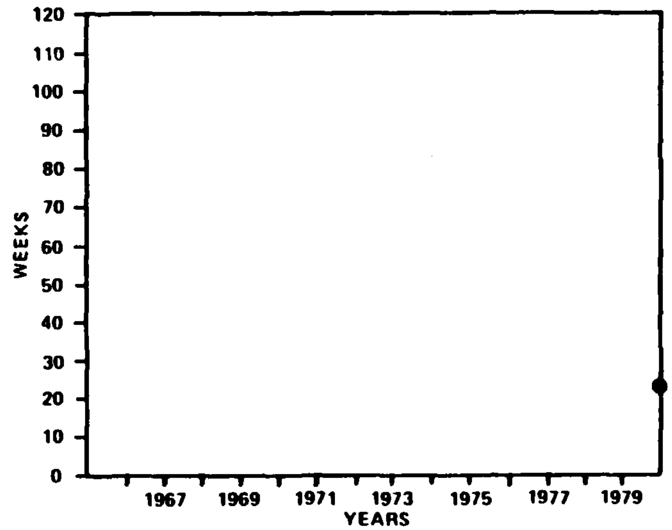

Figure E.1-9. Magnesium, Extrusion.

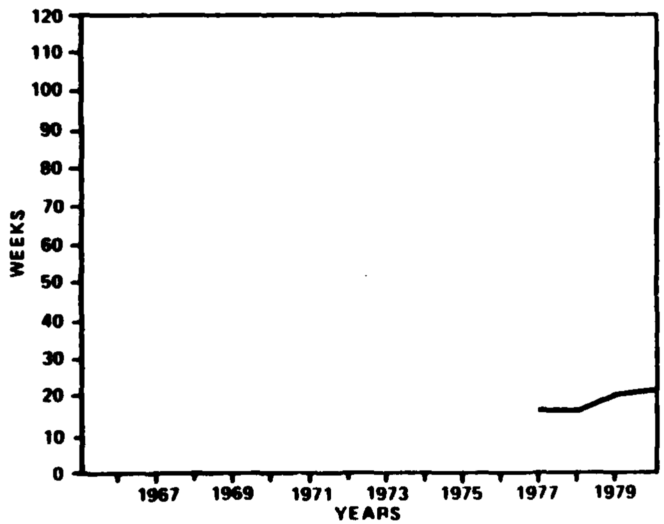

Figure E.1-10. Magnesium, Plate.

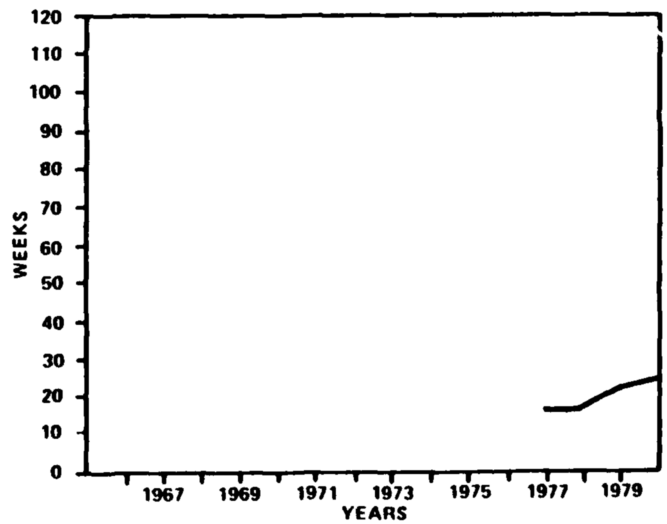

Figure E.1-11. Magnesium, Sheet.

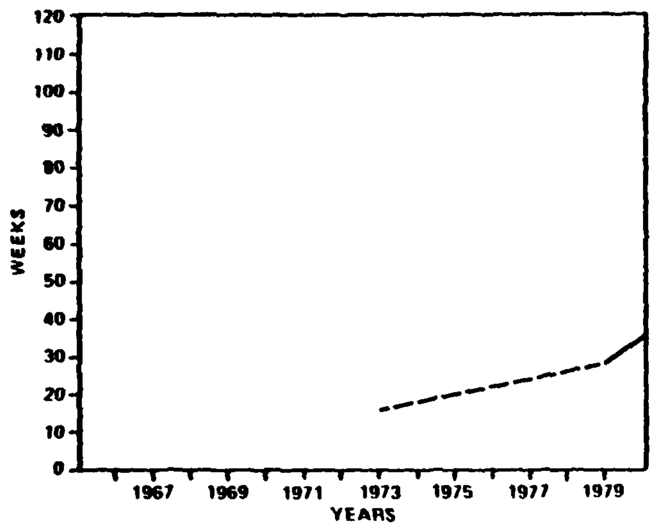

Figure E.1-12. Steel, Bar.

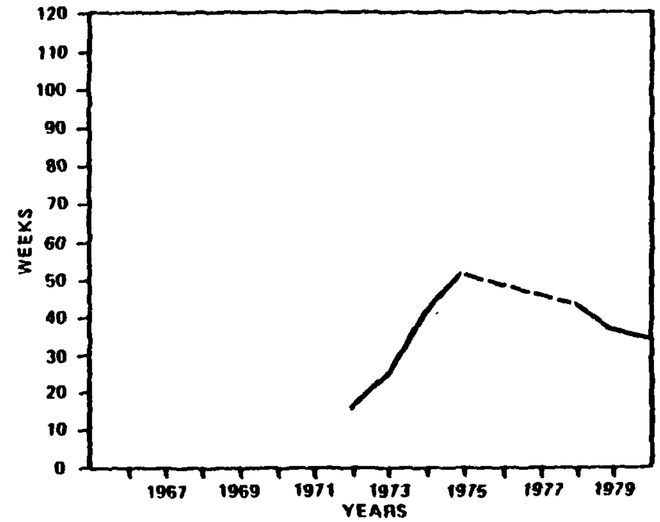

Figure E.1-13. Steel, Extrusion, Light.

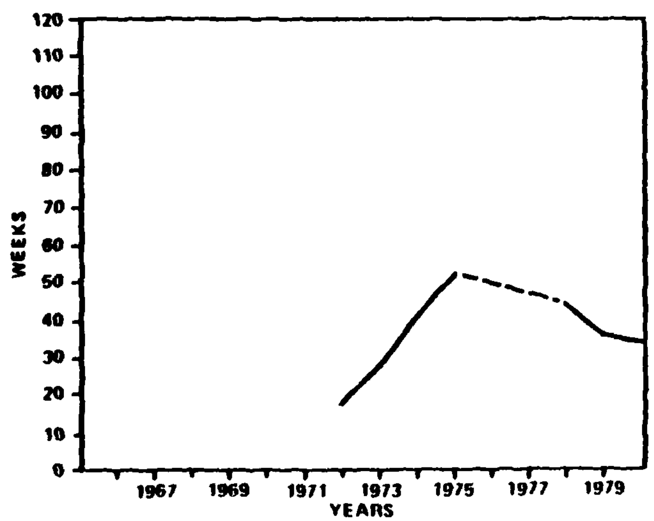

Figure E.1-14. Steel, Extrusion, Heavy.

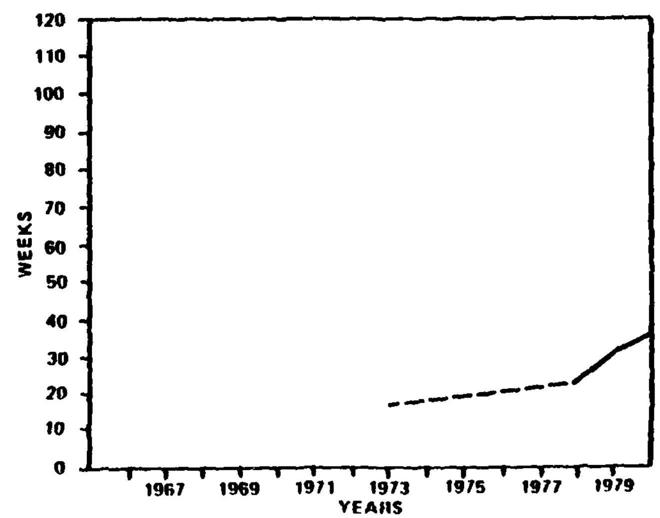

Figure E.1-15. Steel, Plate.

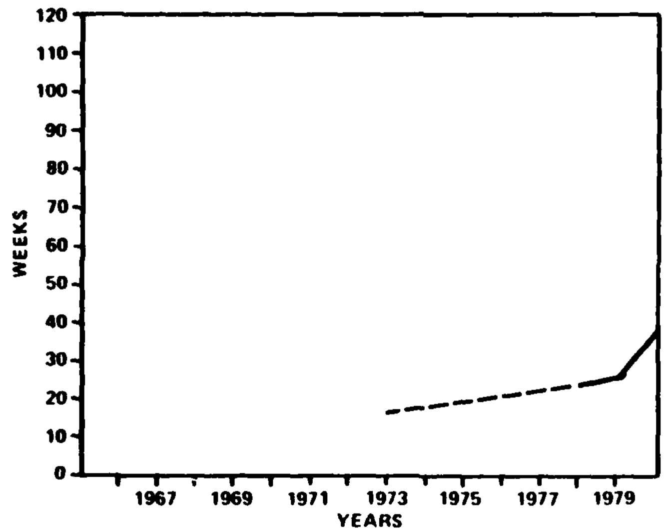

Figure E.1-16. Steel, Rod.

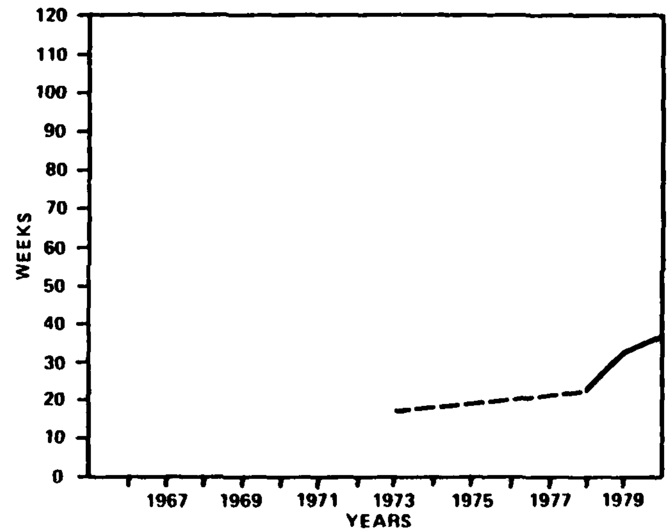

Figure E.1-17. Steel, Sheet.

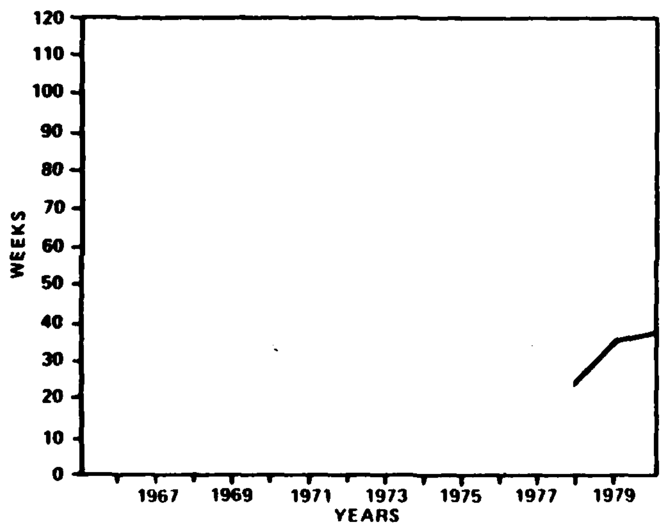

Figure E.1-18. Steel, Tubing.

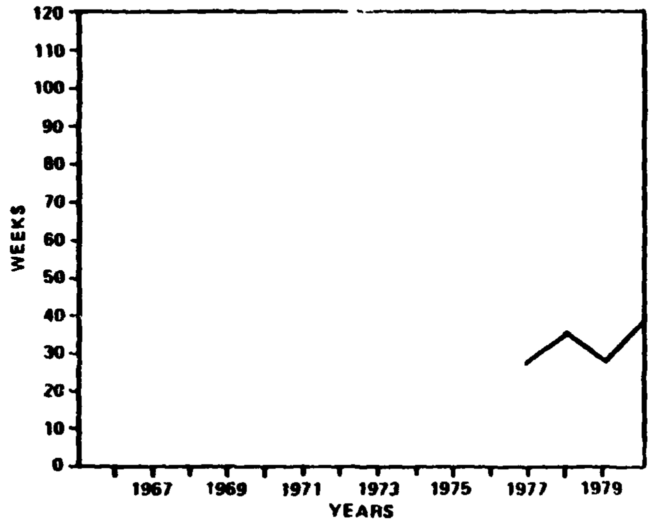

Figure E.1-19. Steel, Stainless, Bar.

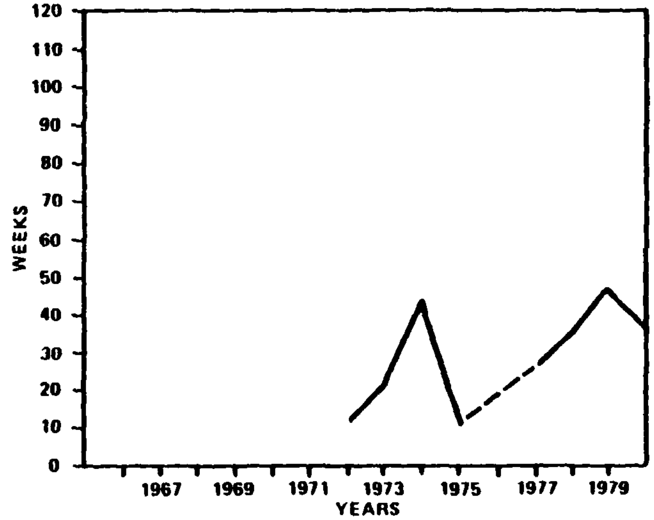

Figure E.1-20. Steel, Stainless, Plate.

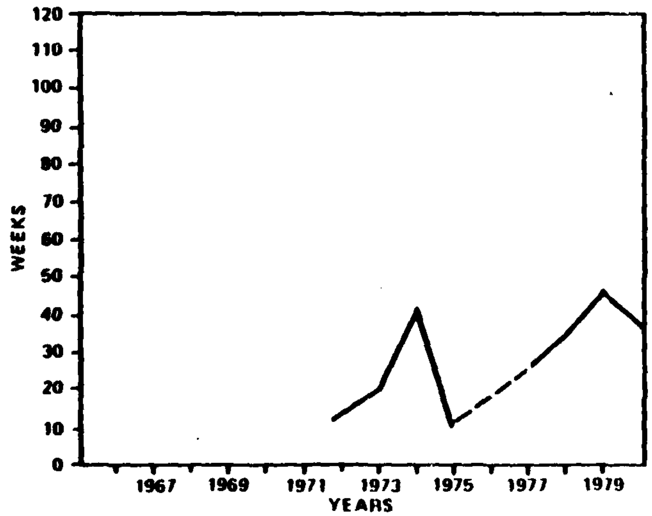

Figure E.1-21. Steel, Stainless, Sheet.

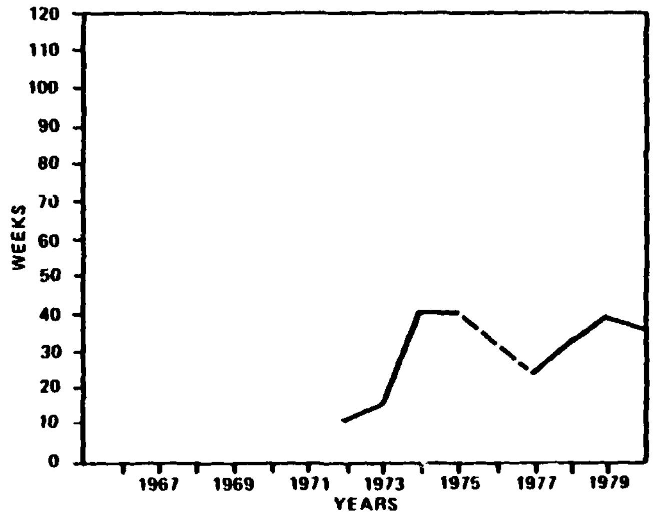

Figure E.1-22. Steel, Stainless, Tubing.

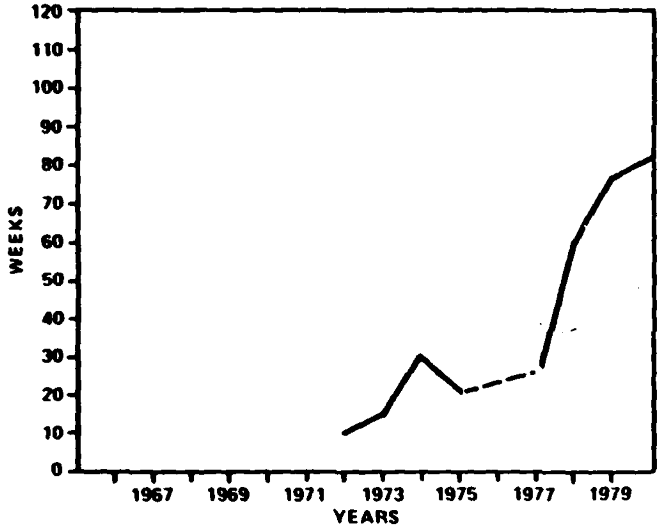

Figure E.1-23. Titanium, Bar.

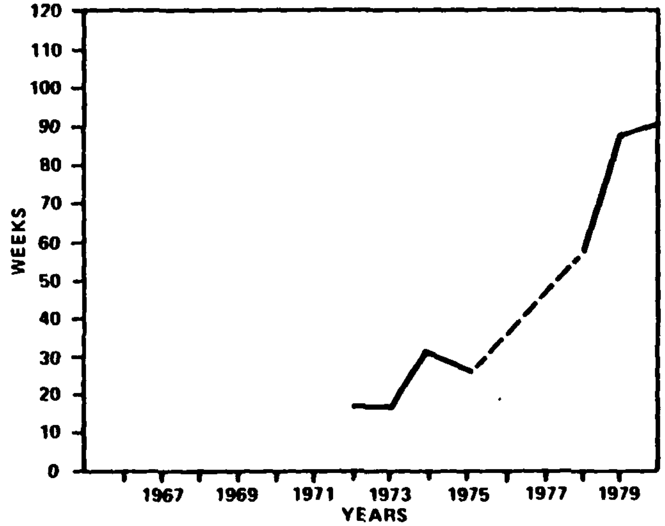

Figure E.1-24. Titanium, Extrusion, Light.

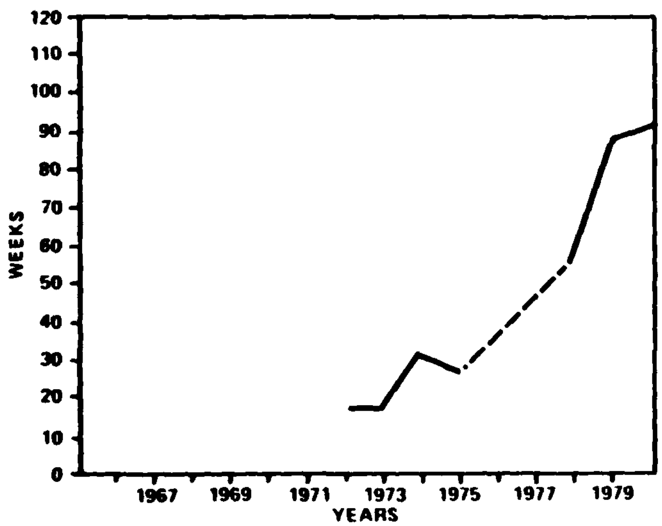

Figure E.1-25. Titanium, Extrusion, Heavy.

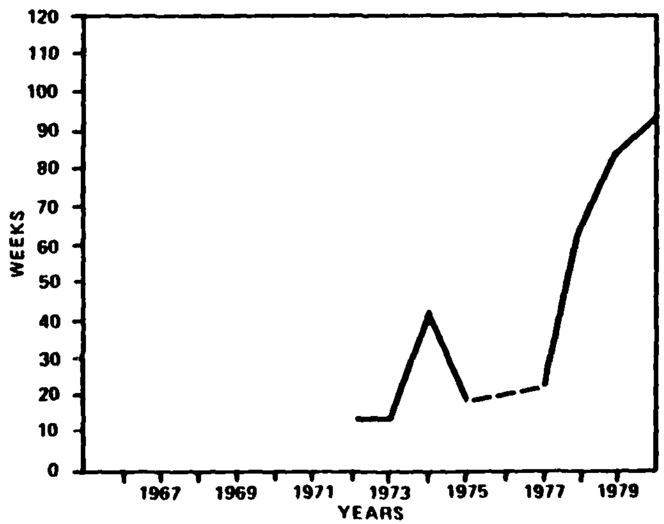

Figure E.1-26. Titanium, Plate.

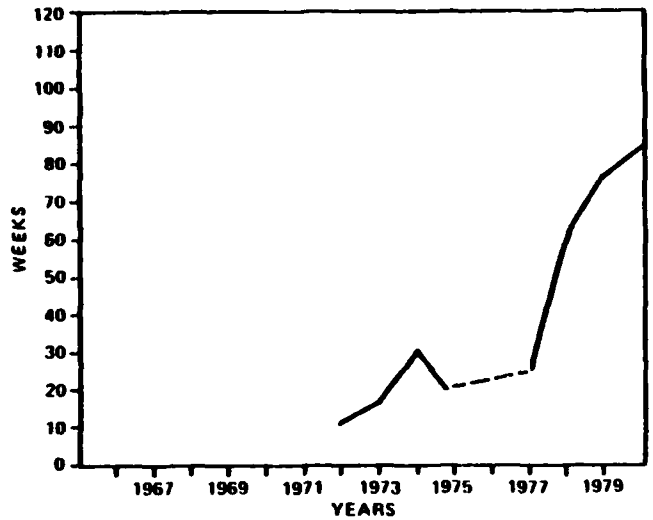

Figure E.1-27. Titanium, Rod.

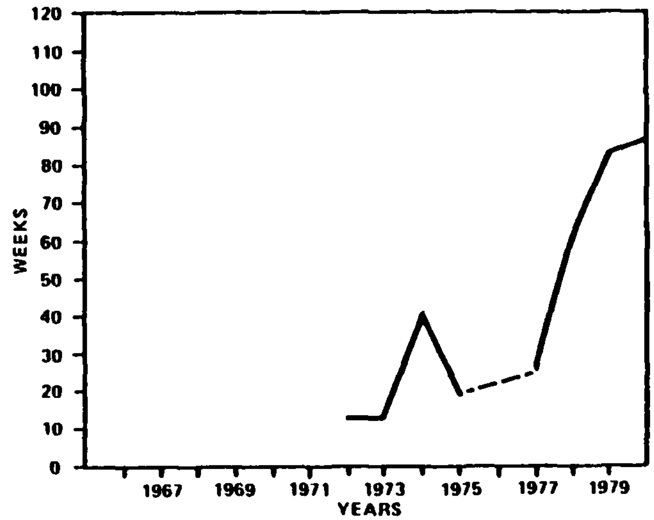

Figure E.1-28. Titanium, Sheet.

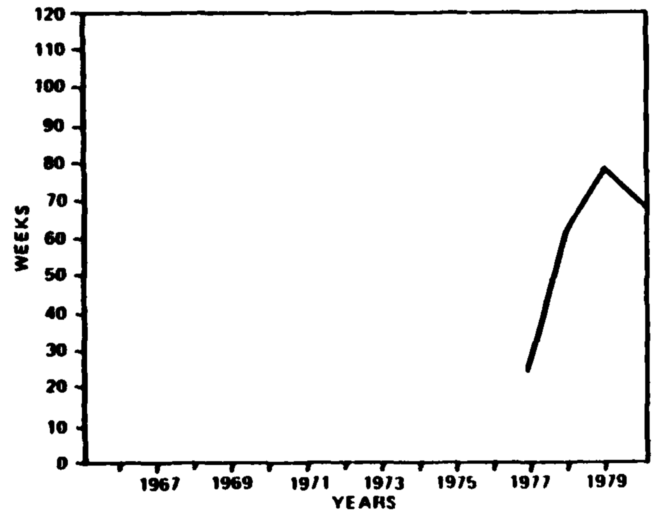

Figure E.1-29. Titanium, Tubing.

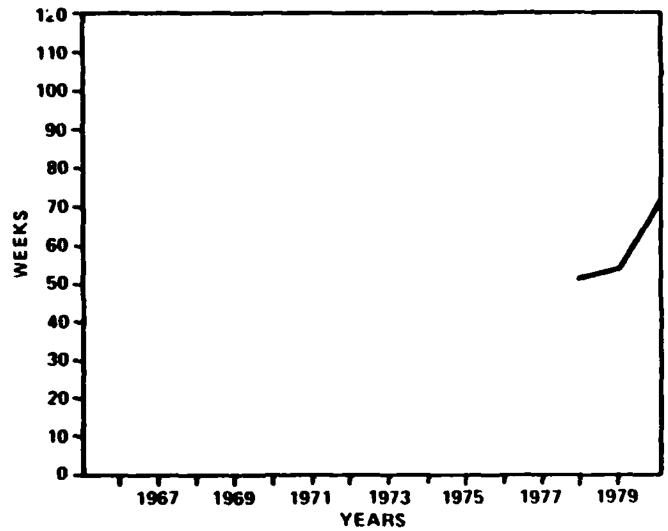

Figure E.1-30. Bearings, Large.

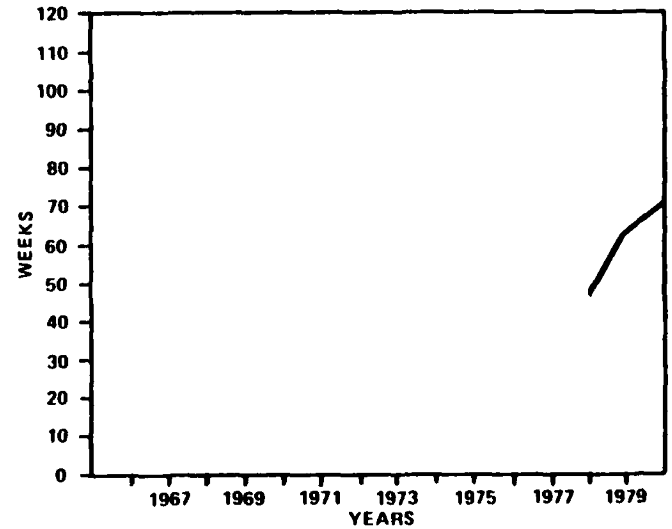

Figure E.1-31. Bearings, Non-Commercial.

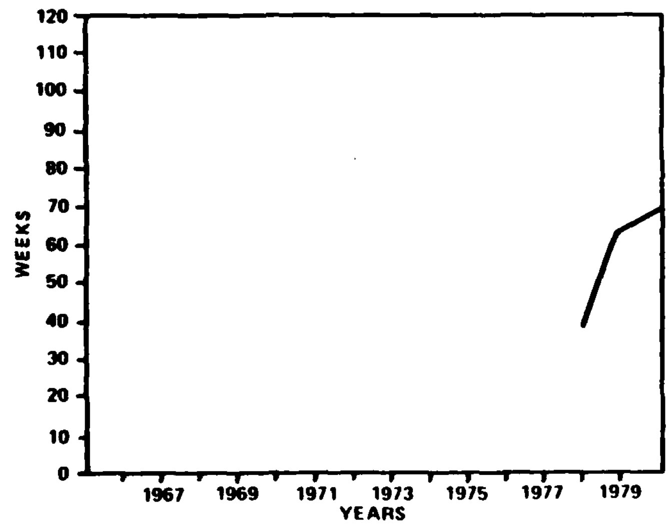

Figure E.1-32. Bearings, Non-Standard.

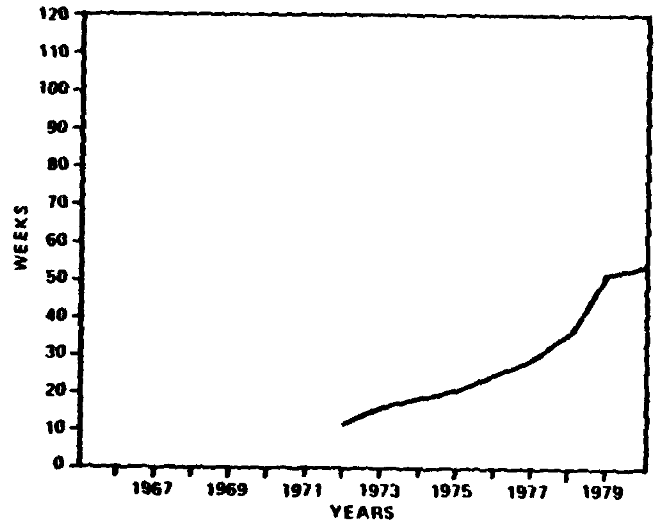

Figure E.1-33. Castings, Aluminum.

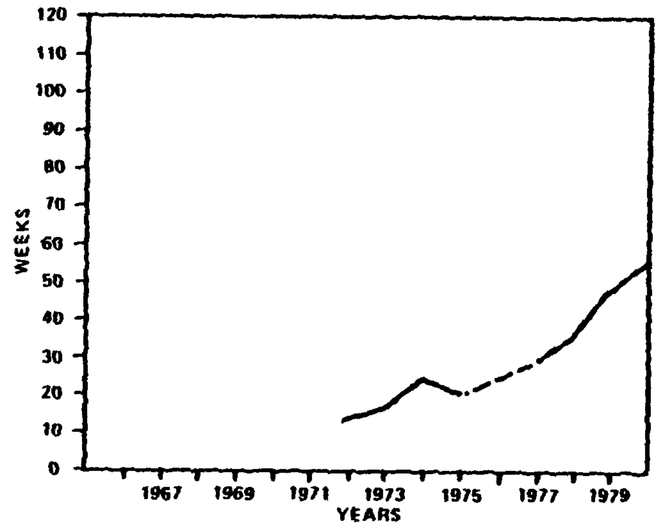

Figure E.1-34. Castings, Steel.

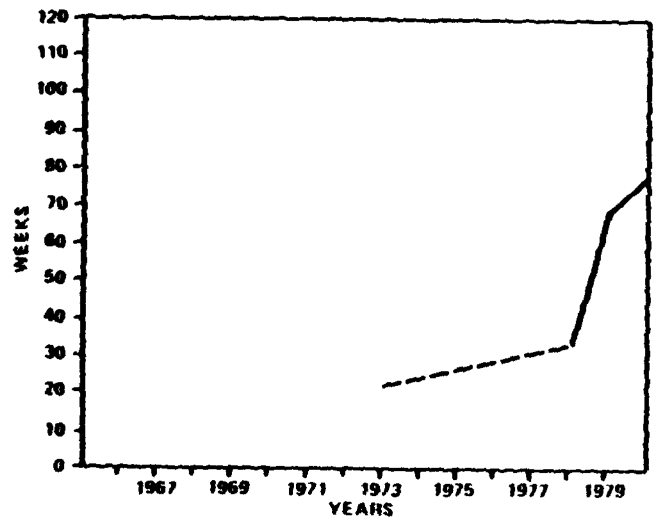

Figure E.1-35. Castings, Titanium.

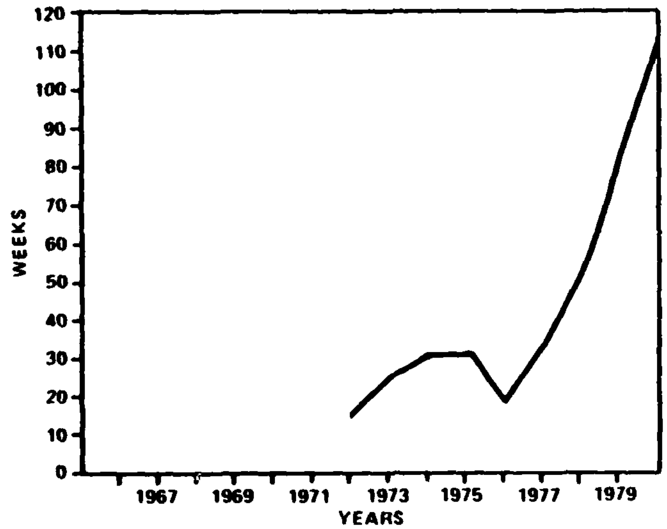

Figure E.1-36. Forgings, Aluminum, Small.

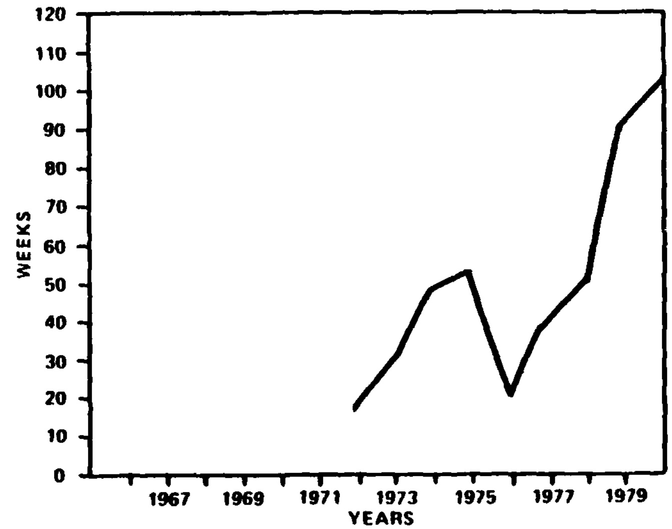

Figure E.1-37. Forgings, Aluminum, Large.

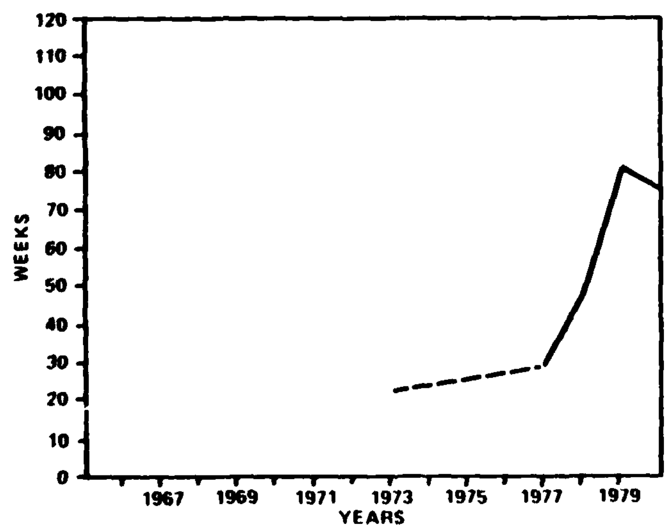

Figure E.1-38. Forgings, Steel, Small.

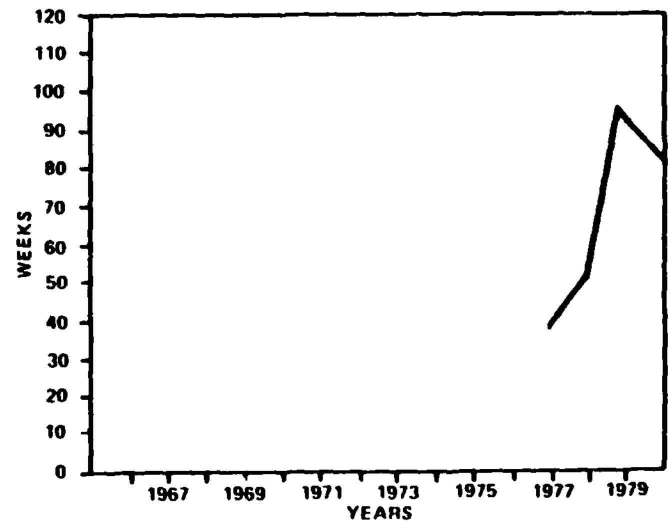

Figure E.1-39. Forgings, Steel, Large.

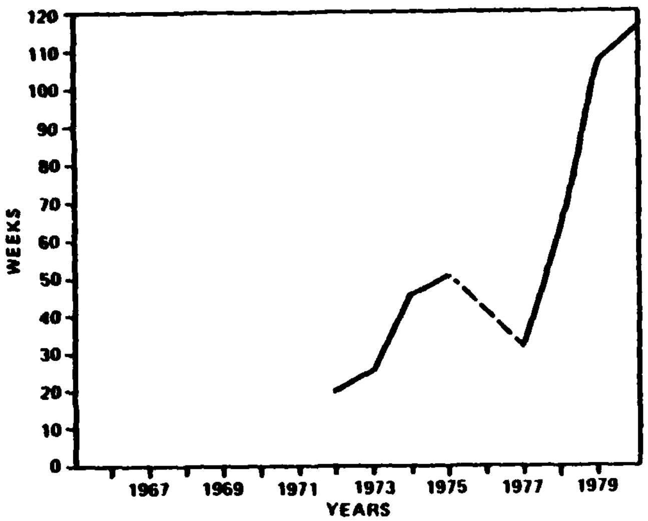

Figure E.1-40. Forgings, Titanium, Small.

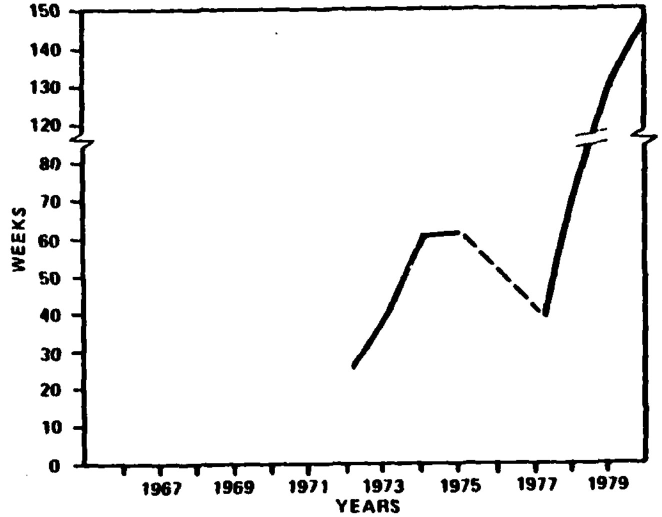

Figure E.1-41. Forgings, Titanium, Large.

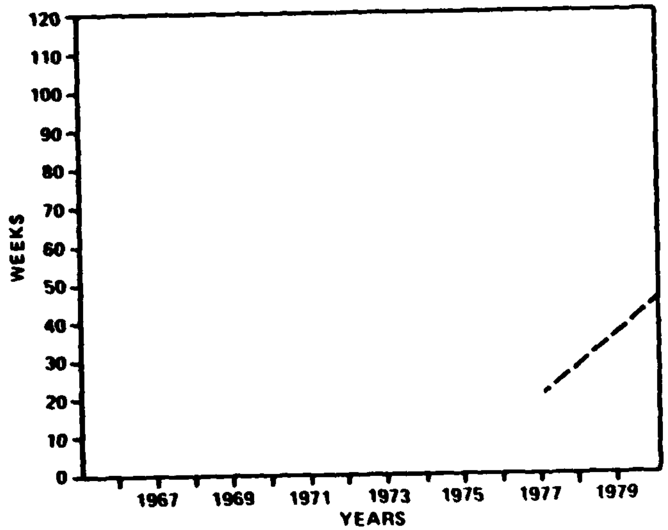

Figure E.1-42. Accelerometers.

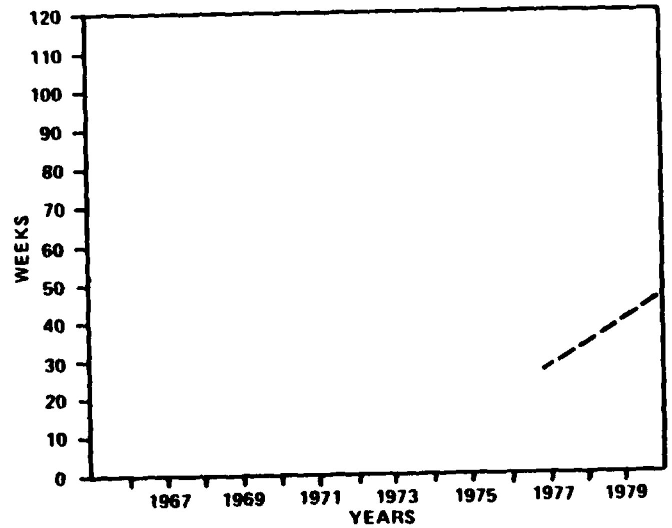

Figure E.1-43. Batteries, Missile.

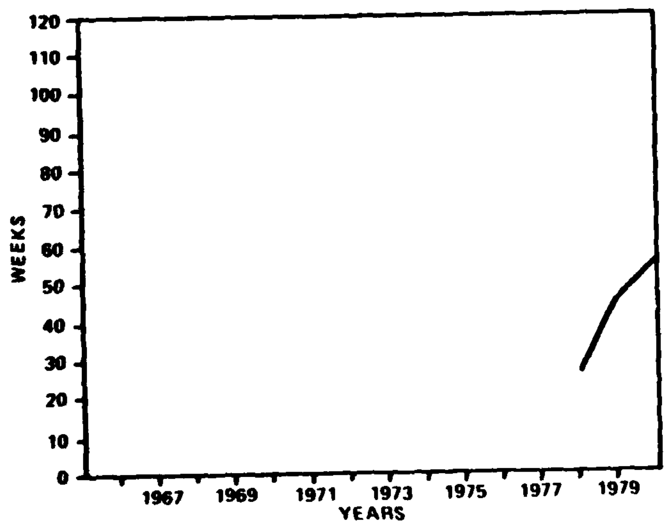

Figure E.1-44. Bolts, Steel Alloy.

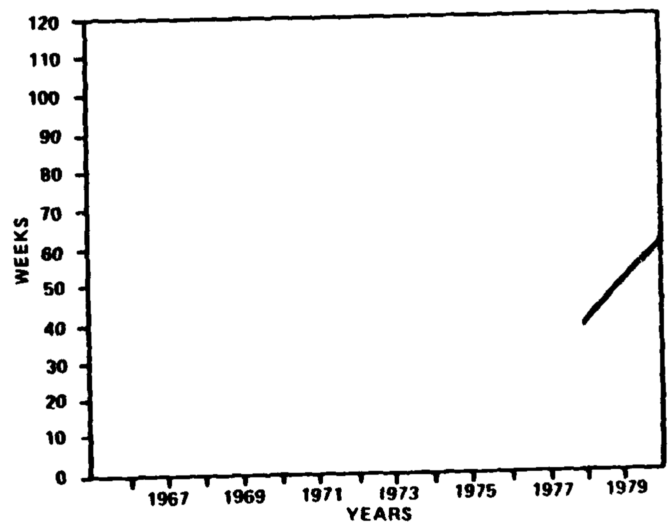

Figure E.1-45. Bolts, Steel, Stainless.

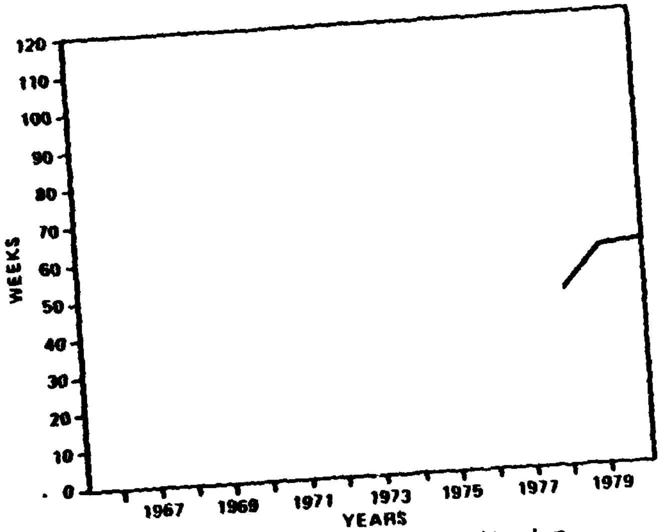

Figure E.1-46. Bolts, Titanium.

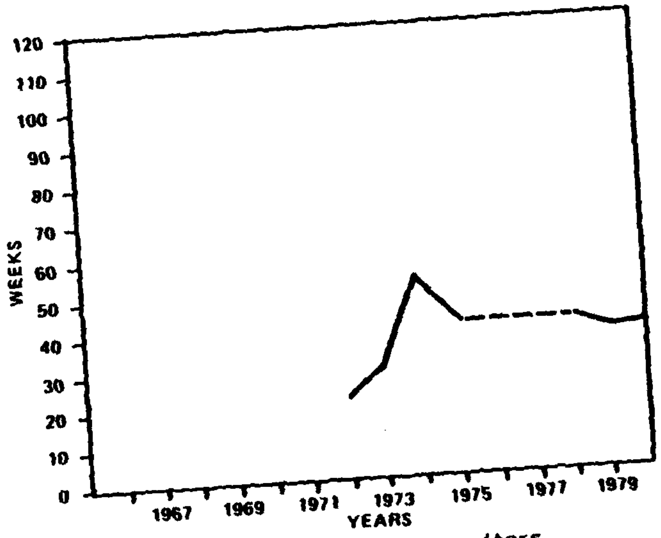

Figure E.1-47. Capacitors.

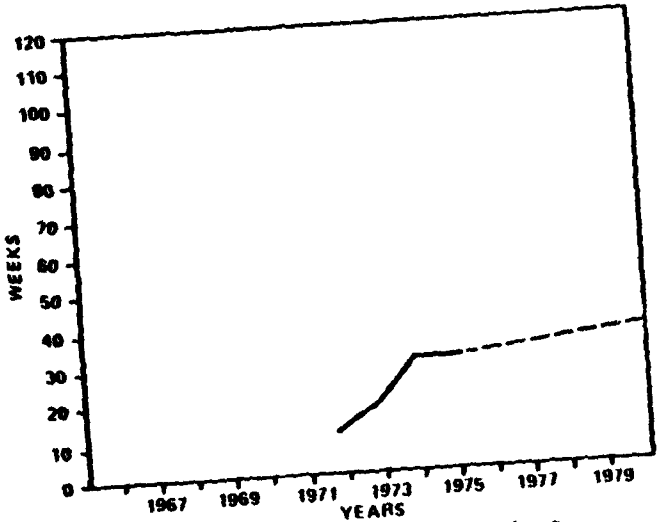

Figure E.1-48. Circuit Breakers.

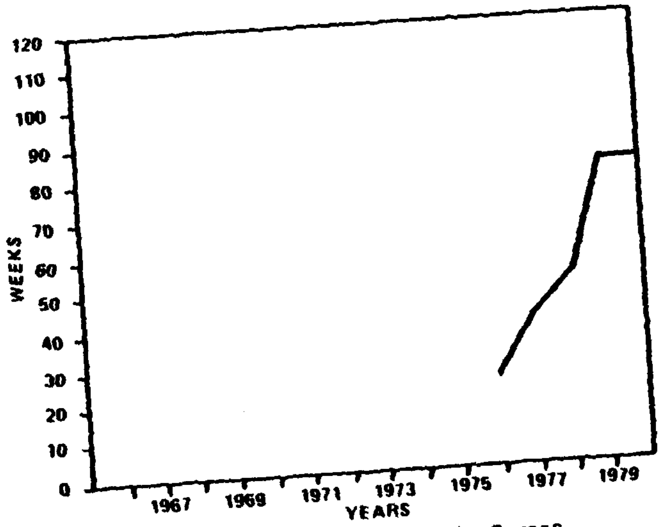

Figure E.1-49. Conduit Covers.

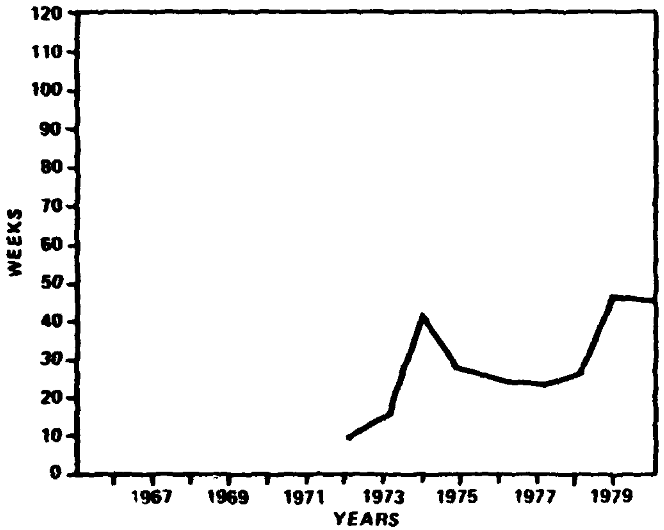

Figure E.1-50. Connectors, *Electrical*.

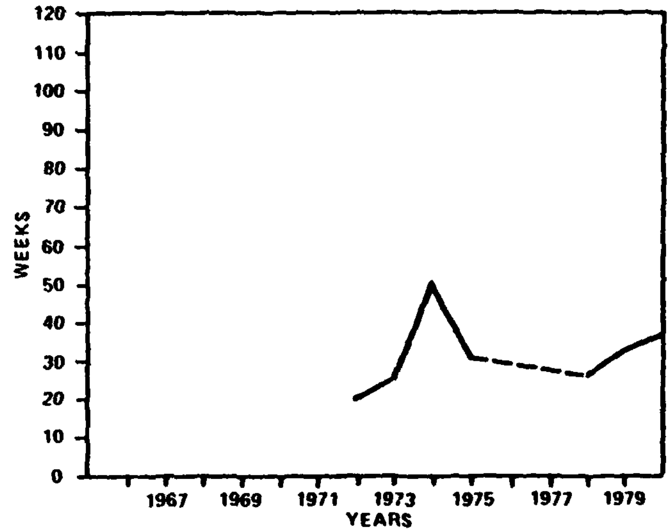

Figure E.1-51. Diodes.

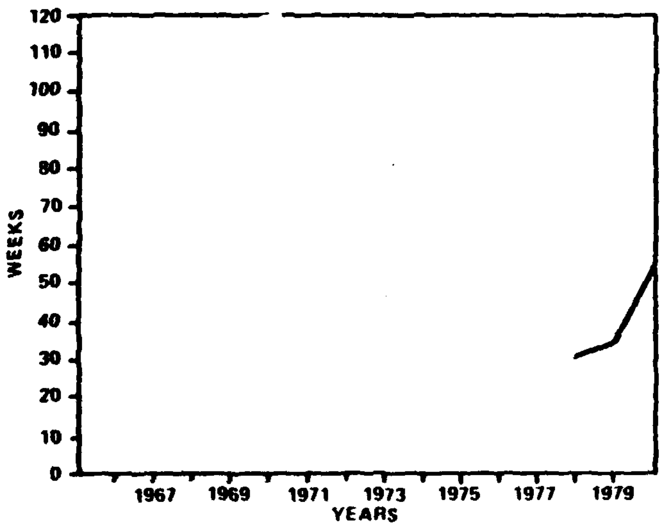

Figure E.1-52. Fasteners, Hy Tuff Alloy.

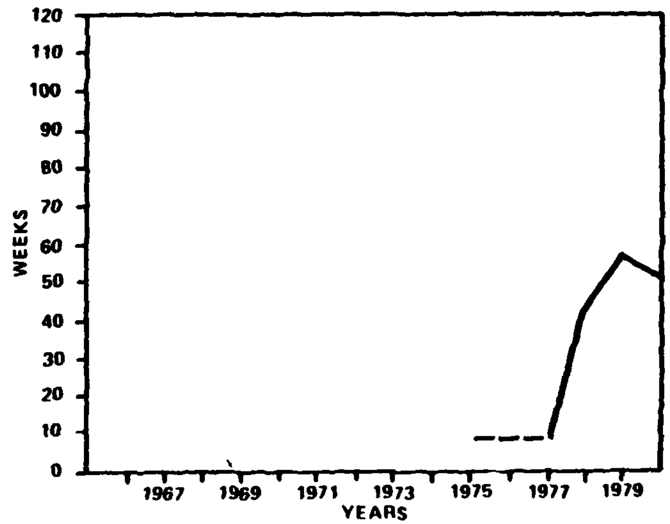

Figure E.1-53. Fasteners, Non-Titanium.

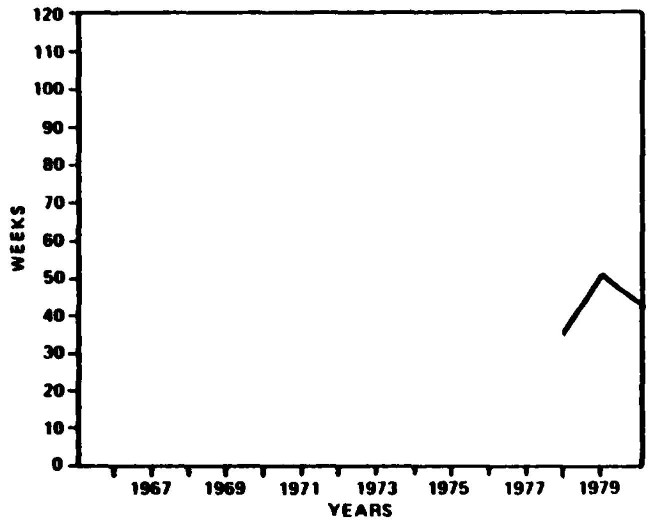

Figure E.1-54. Fasteners, Nut-Self Locking.

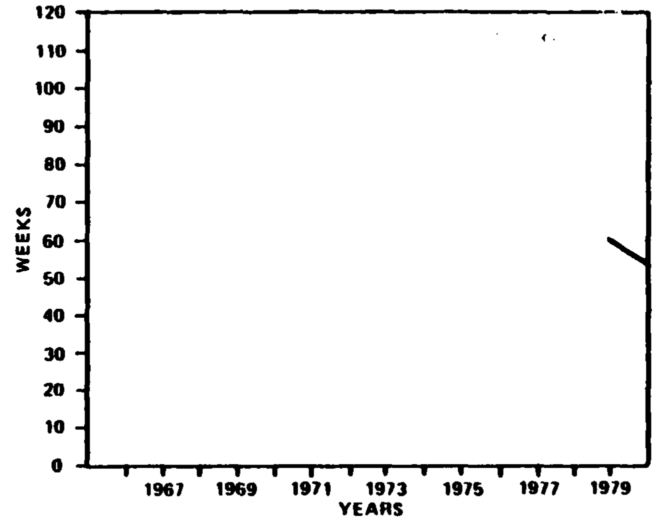

Figure E.1-55. Fasteners, Titanium.

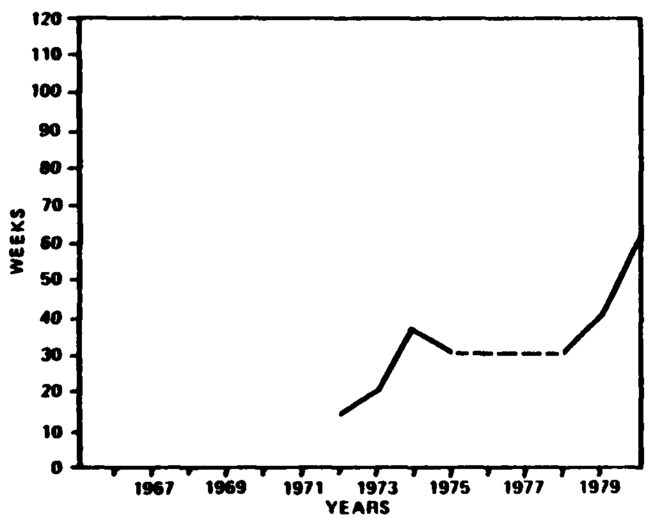

Figure E.1-56. Integrated Circuits (I/Cs).

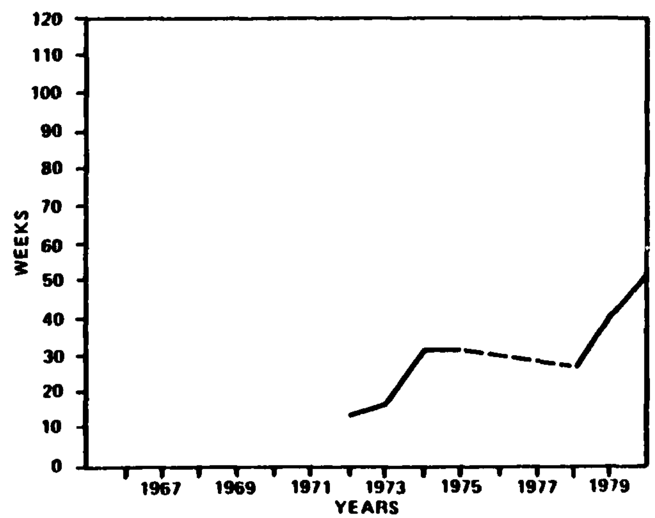

Figure E.1-57. Relays, Electrical.

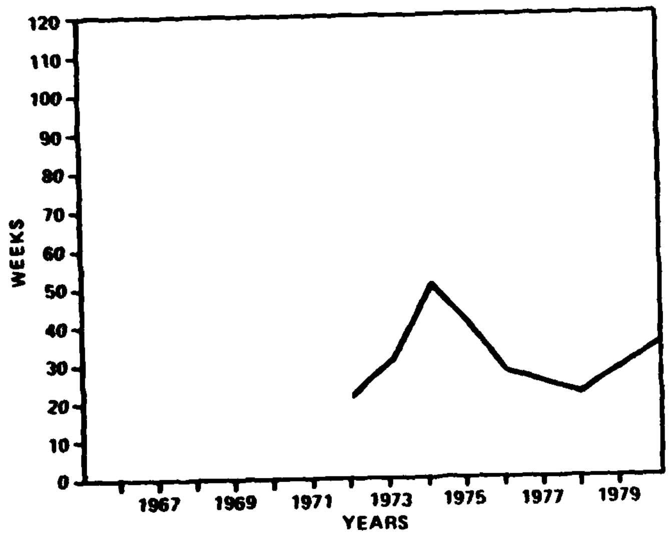

Figure E.1-58. Resistors, Electrical.

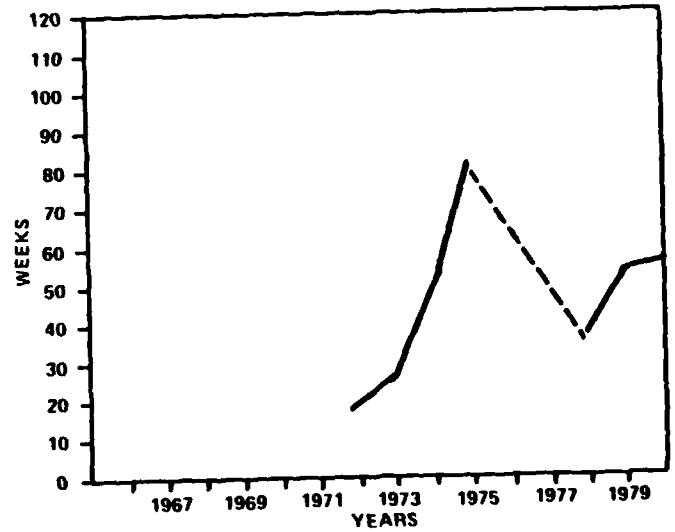

Figure E.1-59. Rod Ends.

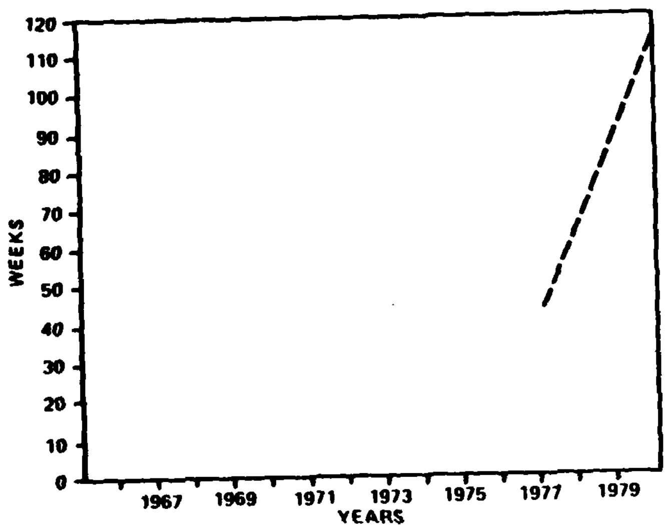

Figure E.1-60. Speed Brake Actuator.

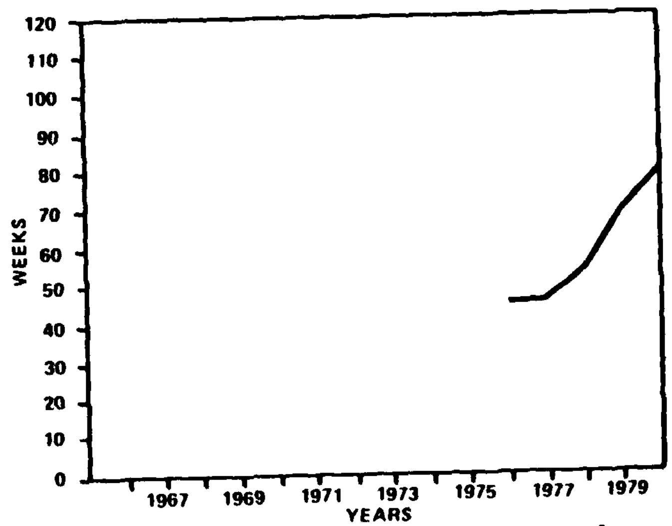

Figure E.1-61. Stabilizer, Horizontal, Aircraft.

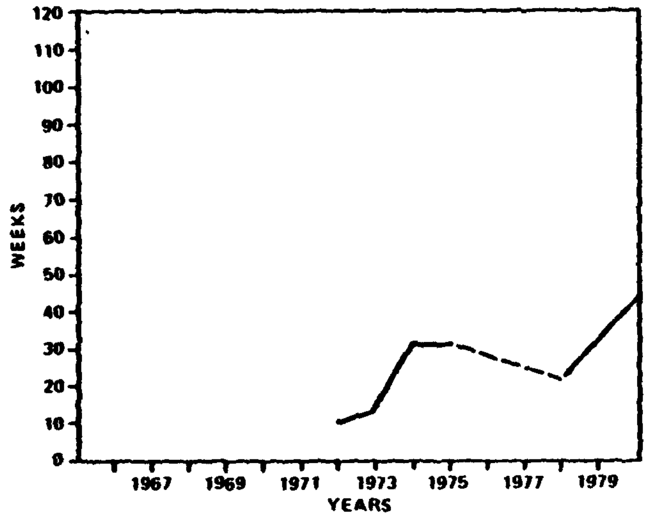

Figure E.1-62. Switches, Electrical.

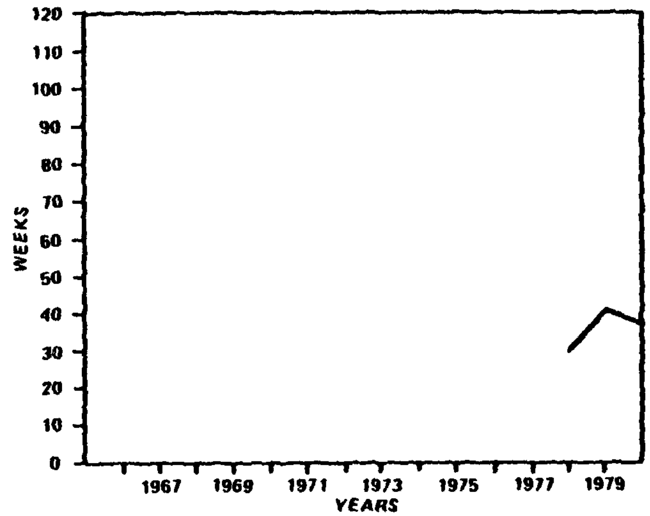

Figure E.1-63. Transformers, Electrical.

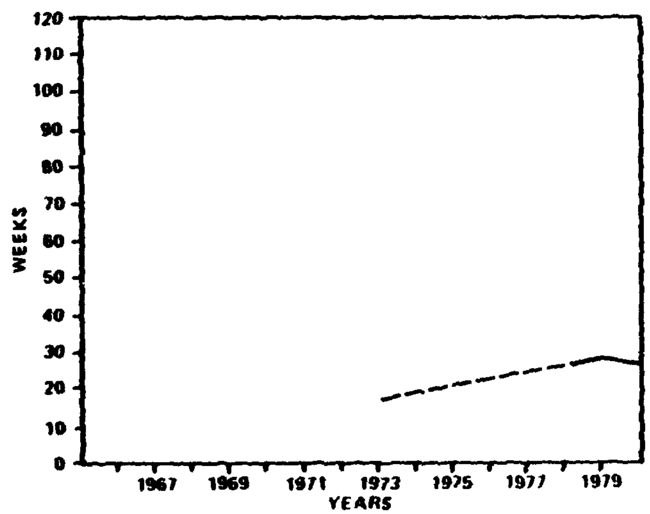

Figure E.1-64. Transistors, Electrical.

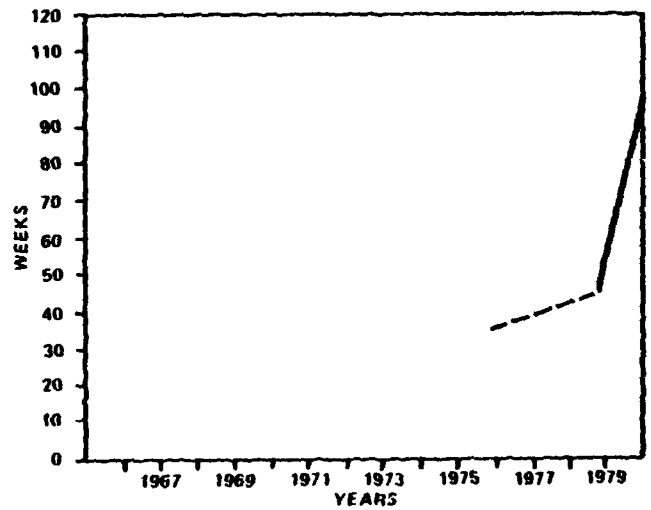

Figure E.1-65. Tubes, Traveling Wave.

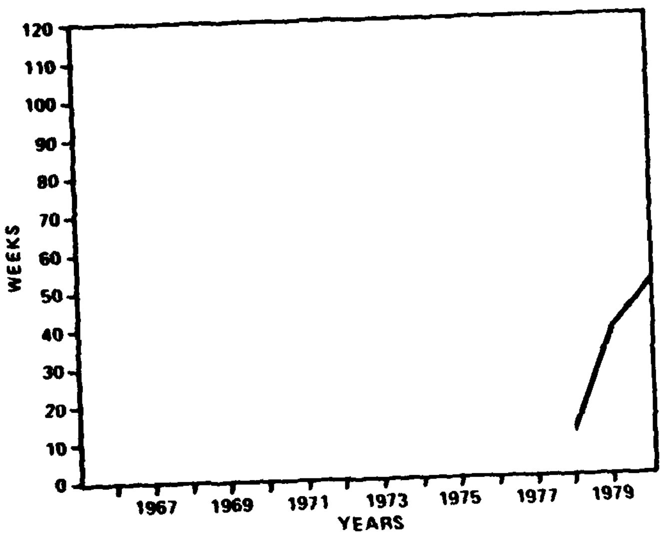

Figure E.1-66. Washers.

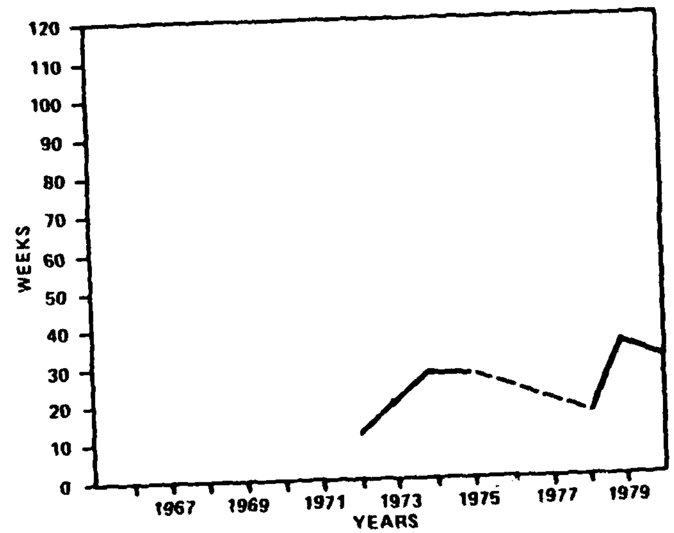

Figure E.1-67. Wire, Electrical.

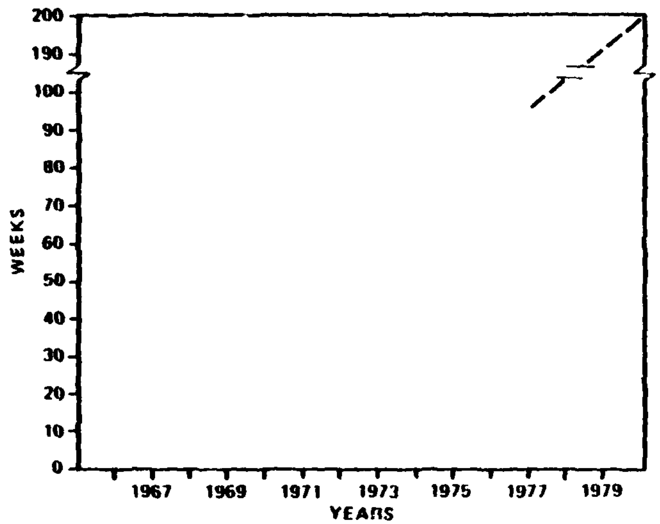

Figure E.1-68. Airframe.

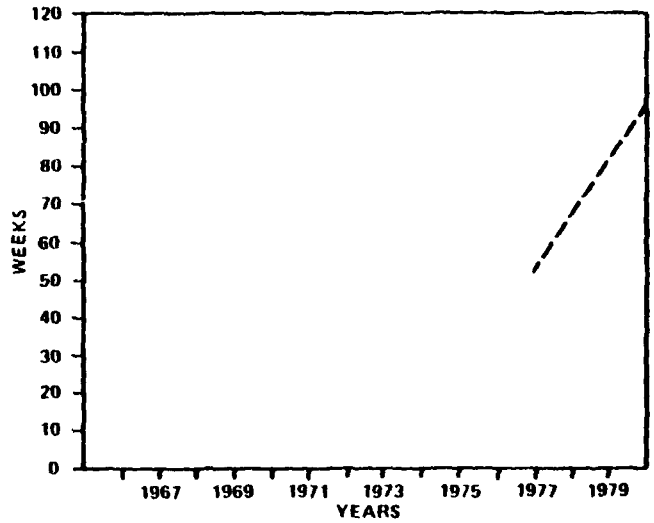

Figure E.1-69. Ammunition Handling System.

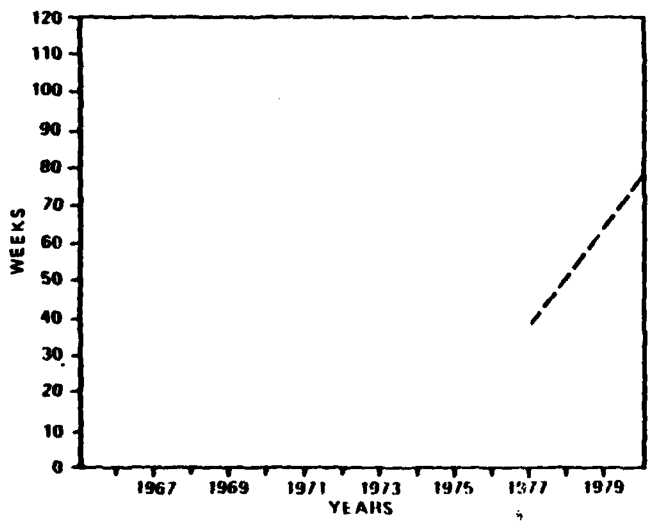

Figure E.1-70. Anti-Skid System.

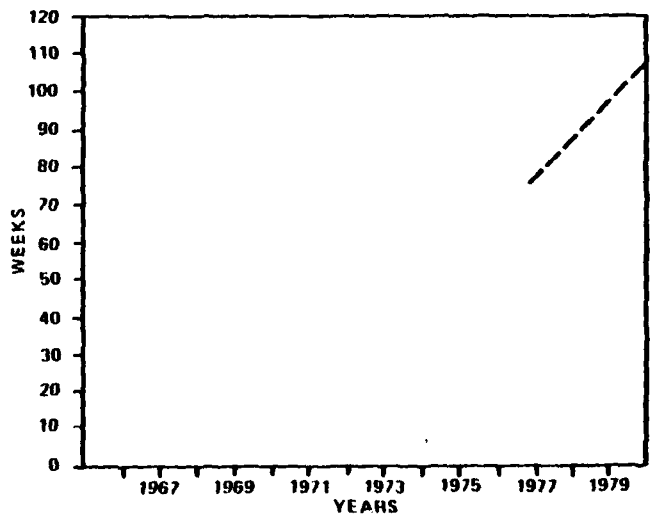

Figure E.1-71. Attitude, Velocity and Control System, Satellite (GPS NavStar).

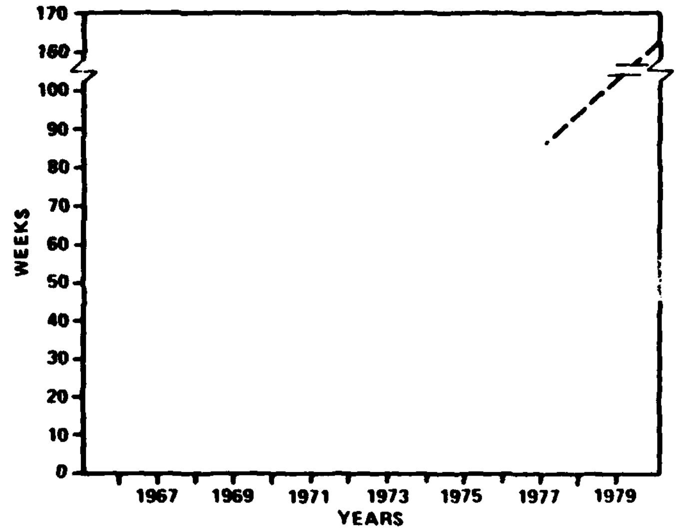

Figure E.1-72. Engine, Aircraft.

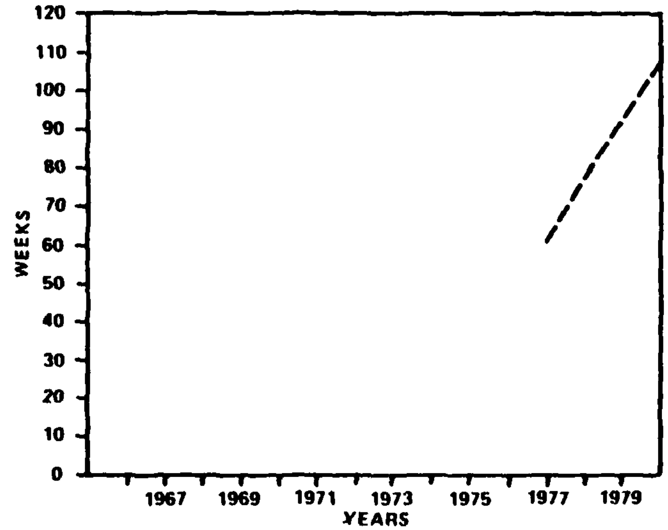

Figure E.1-73. Environmental Controls.

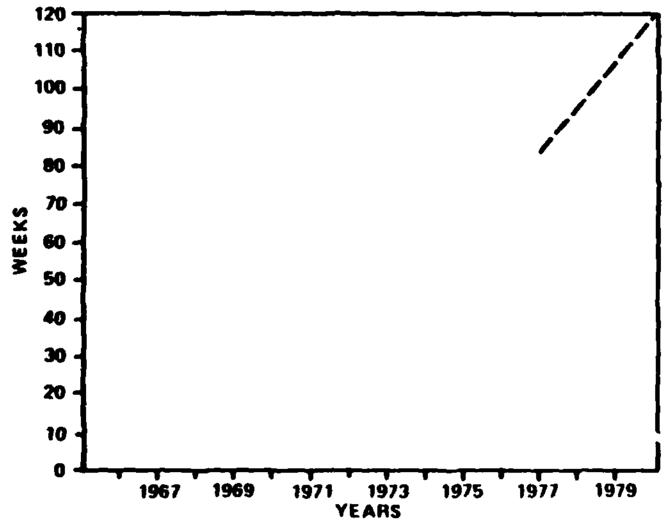

Figure E.1-74. Gun, Aircraft.

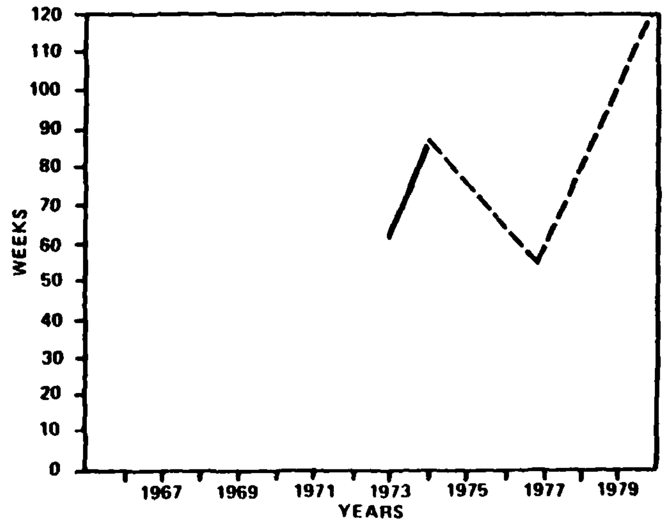

Figure E.1-75. Landing Gear, Aircraft.

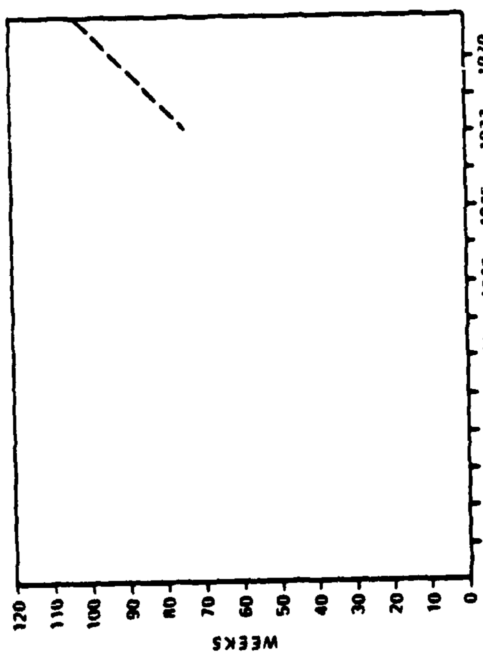

Figure E.1-76. Navigation System, Satellite (GPS NavStar).

Tab E.2 - Shipbuilding Long Lead Items

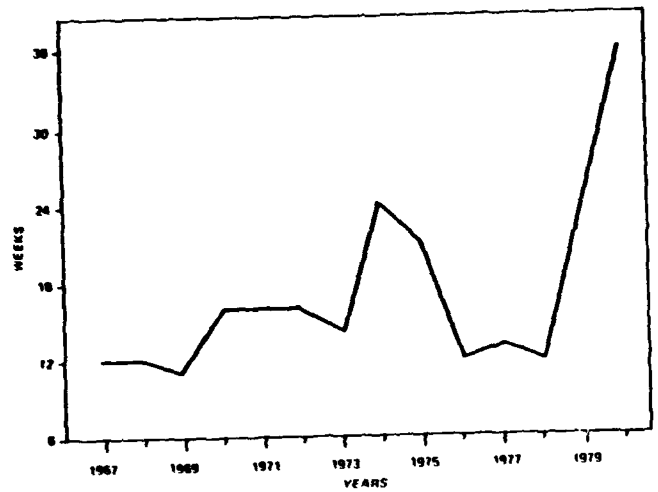

Figure E.2-1. Aluminum Alloys, Plate, Heat-Treatable.

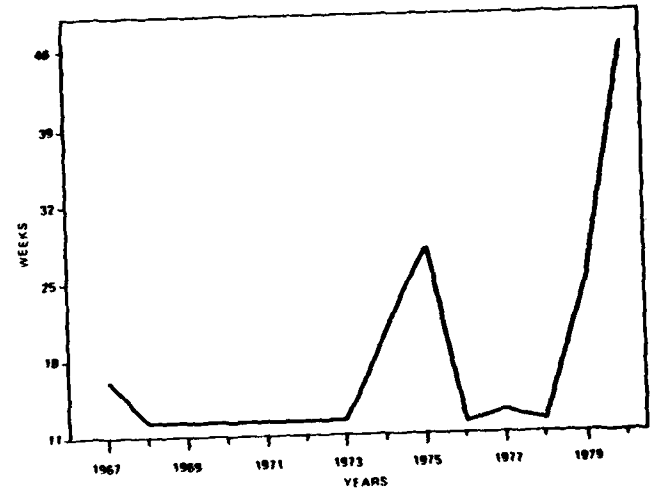

Figure E.2-2. Aluminum Alloys, Shapes, Extruded, Special or Complex Sections.

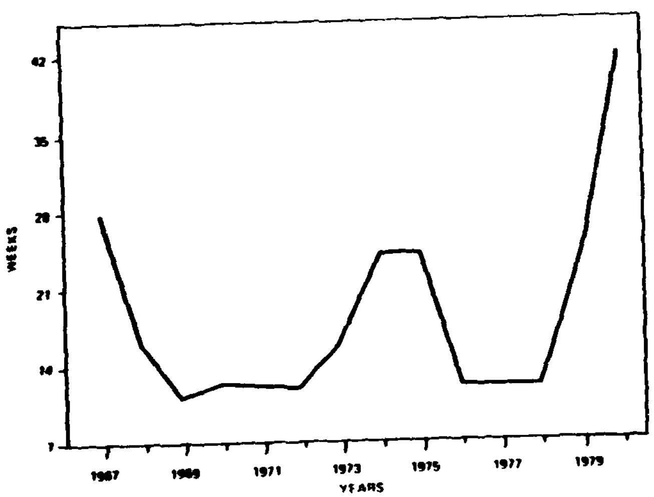

Figure E.2-3. Aluminum Alloys Tubing, Round, Drawn, Above 6.0" Outer Diameter.

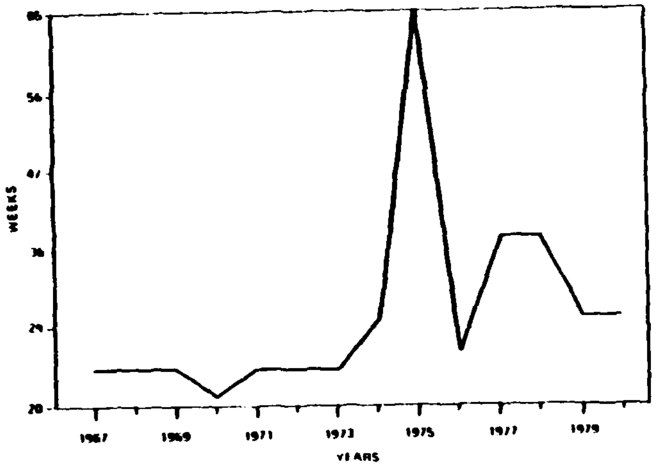

Figure E.2-4. Nickel Alloys, Pipe, Cold Drawn, 6.625" Outer Diameter and Above.

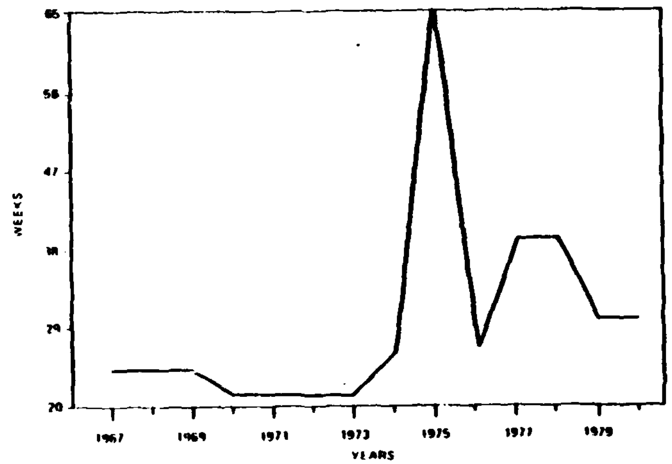

Figure E.2-5. Nickel Alloys, Tubing, Cold Drawn, 5.0" Outer Diameter and Above.

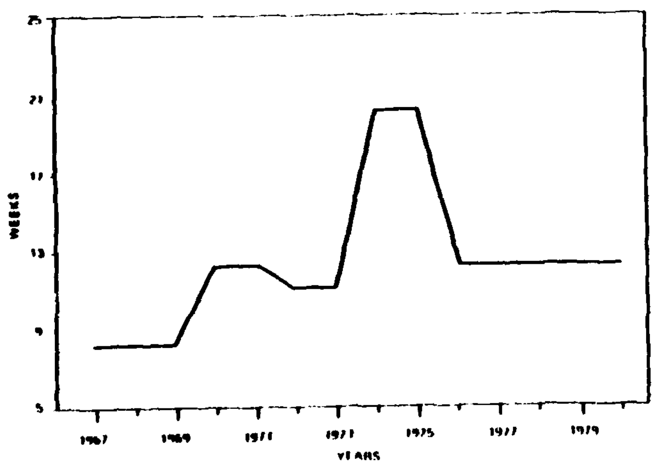

Figure E.2-6. Steel-Carbon, Pipe & Tubing, Seamless.

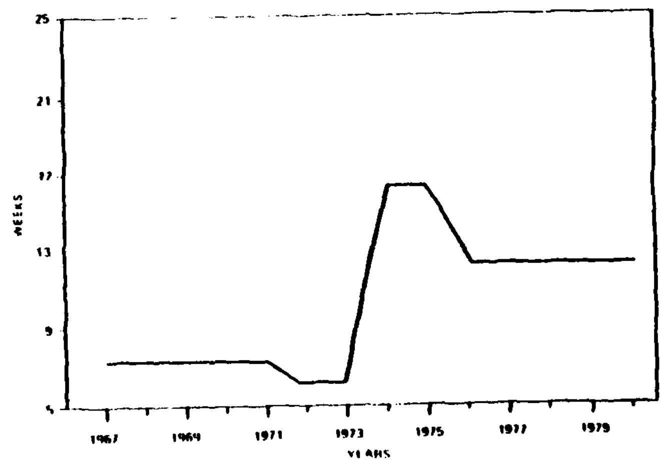

Figure E.2-7. Steel-Carbon, Pipe & Tubing, Welded.

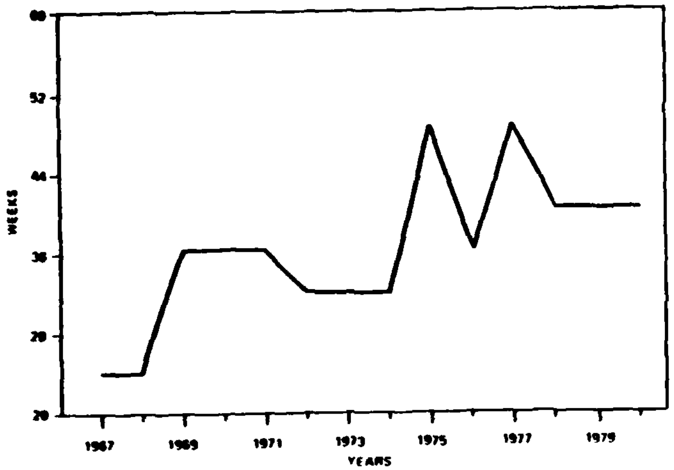

Figure E.2-8. Bearing, Propulsion Shafting, Stern Tube & Strut, 6" to 15" Diameter.

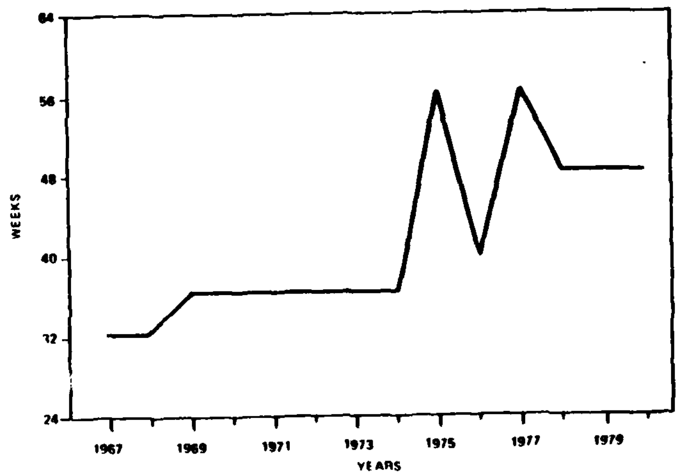

Figure E.2-9. Bearing, Propulsion Shafting, Stern Tube & Strut, 16" to 36" Diameter.

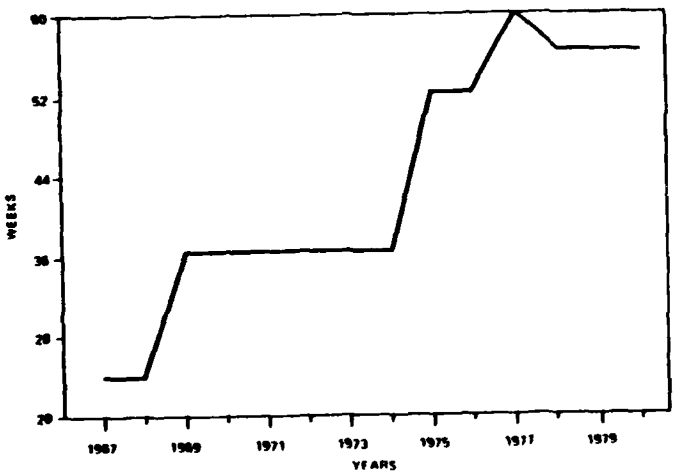

Figure E.2-10. Bearing, Thrust, Main, Separately Mounted, 5" to 22" Diameter.

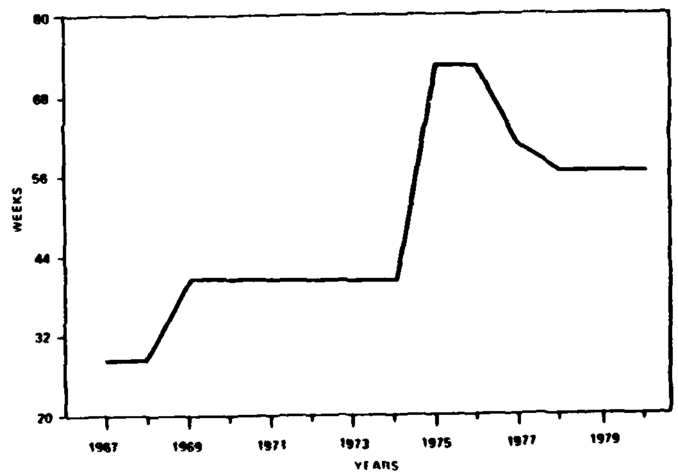

Figure E.2-11. Bearing, Thrust, Main, Separately Mounted, 23" to 33" Diameter.

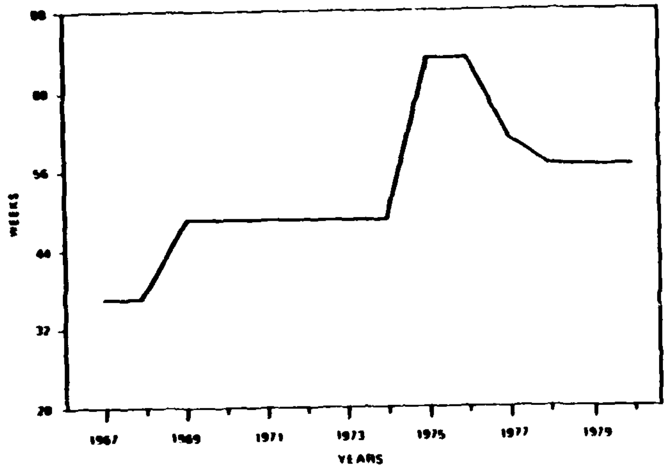

Figure E.2-12. Bearing, Thrust, Main, Separately Mounted, 34" to 45" Diameter.

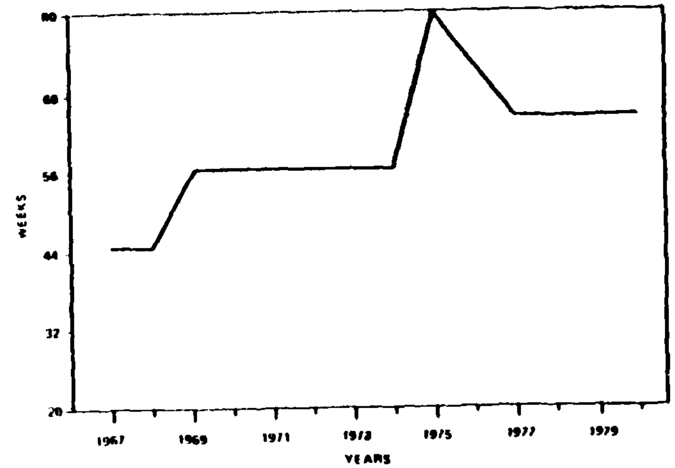

Figure E.2-13. Bearing, Thrust, Main, Separately Mounted, 45" to 60" Diameter.

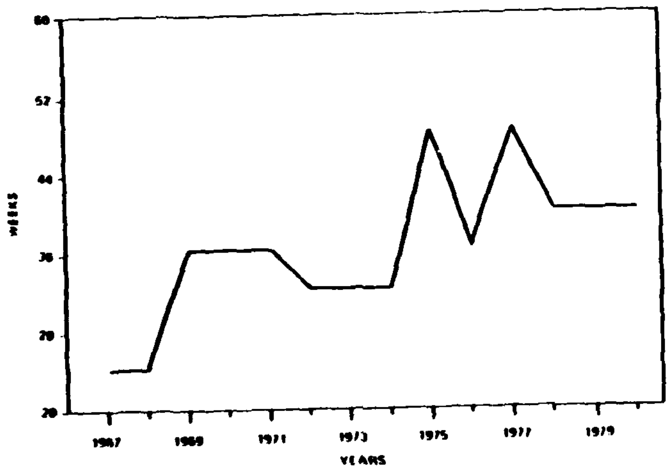

Figure E.2-14. Bearing, Propulsion Shafting, Stern Tube & Strut, 6" to 15" Diameter.

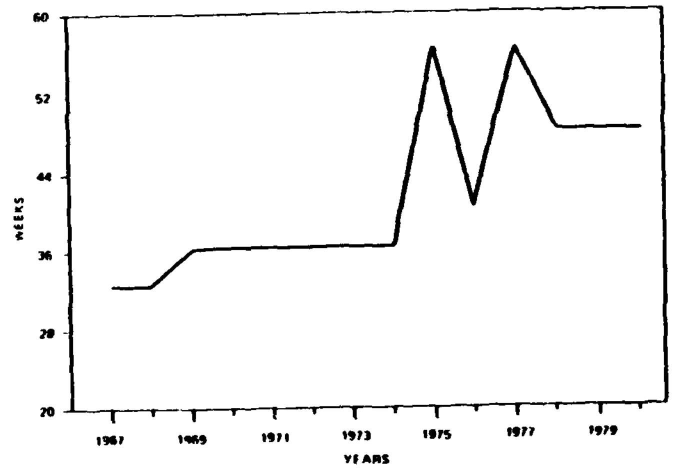

Figure E.2-15. Bearing, Propulsion Shafting, Stern Tube & Strut, Above 15" Diameter.

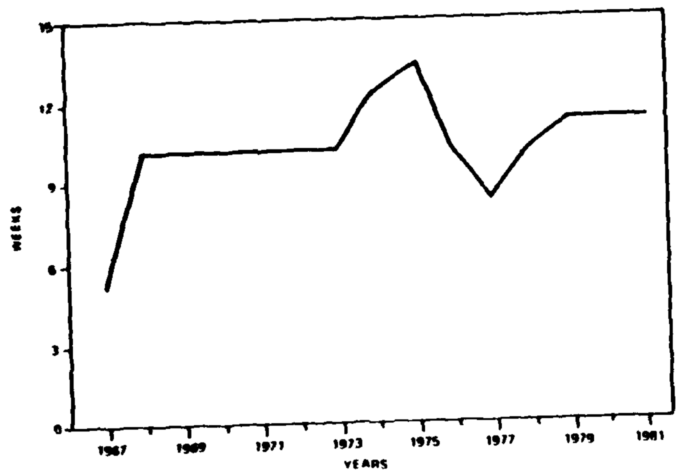

Figure E.2-16. Castings, Aluminum, Large.

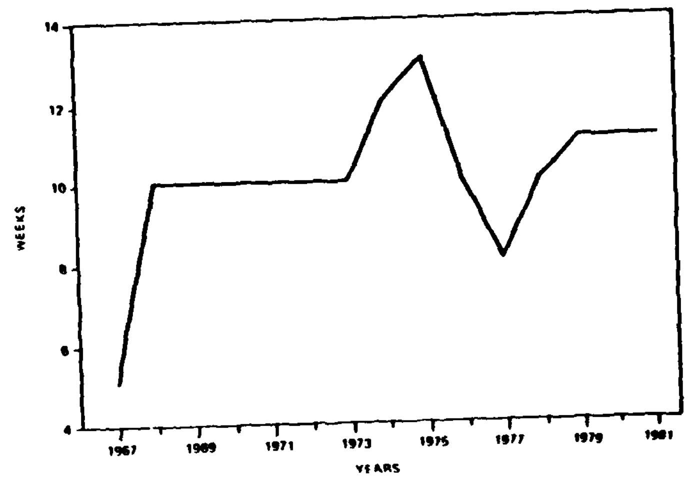

Figure E.2-17. Castings, Aluminum Alloy, Permanent Mold.

Figure E.2-18. Castings (Sand), Steel Alloy, Small or Simple Shapes.

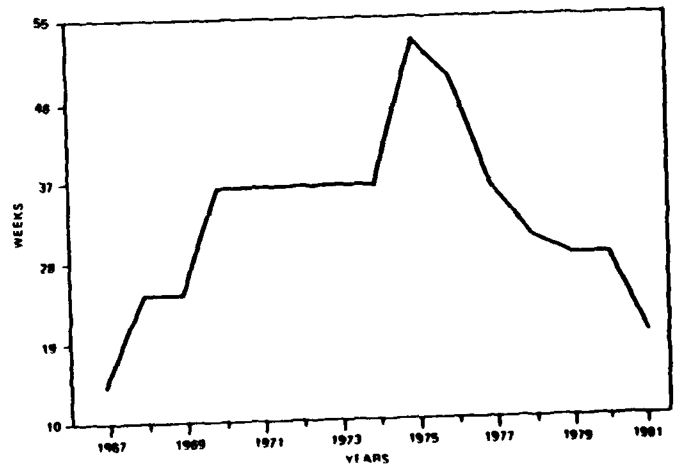

Figure E.2-19. Castings (Sand), Steel Alloy, Submarine Quality.

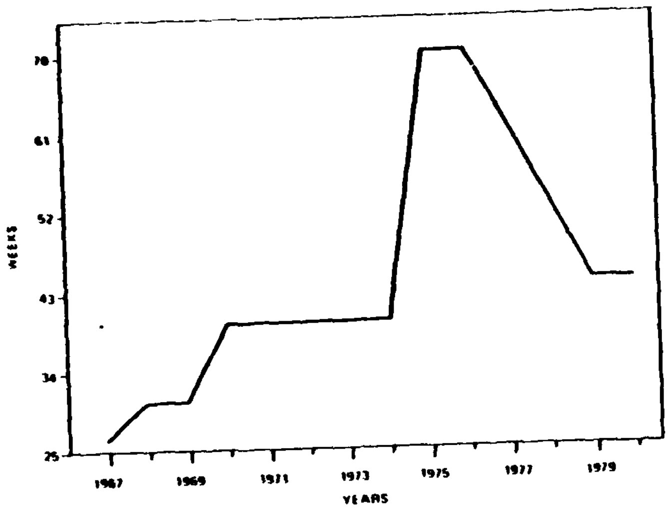

Figure E.2-20. Castings, Stern.

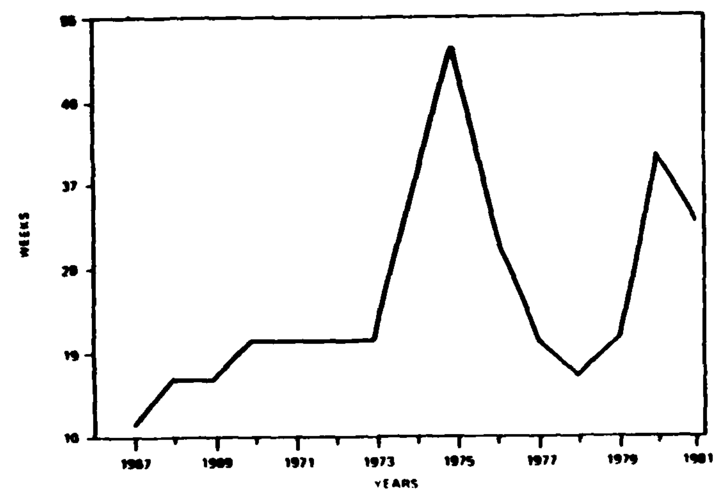

Figure E.2-21. Forgings, Copper Base Alloy, Large or Complicated Shapes.

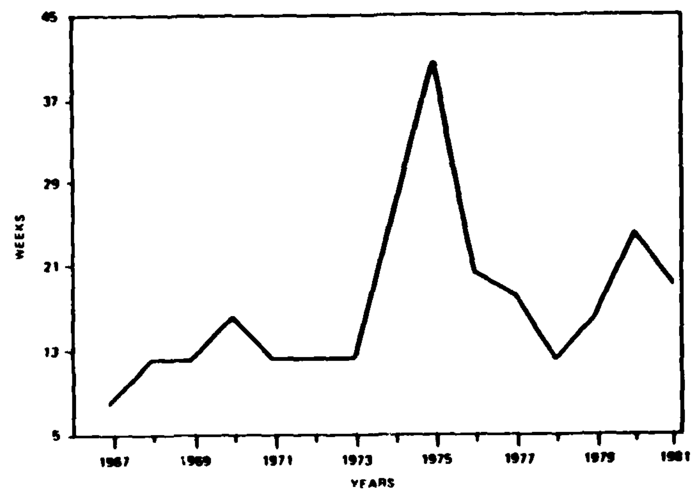

Figure E.2-22. Forgings, Copper Base Alloy, Small or Simple Shapes.

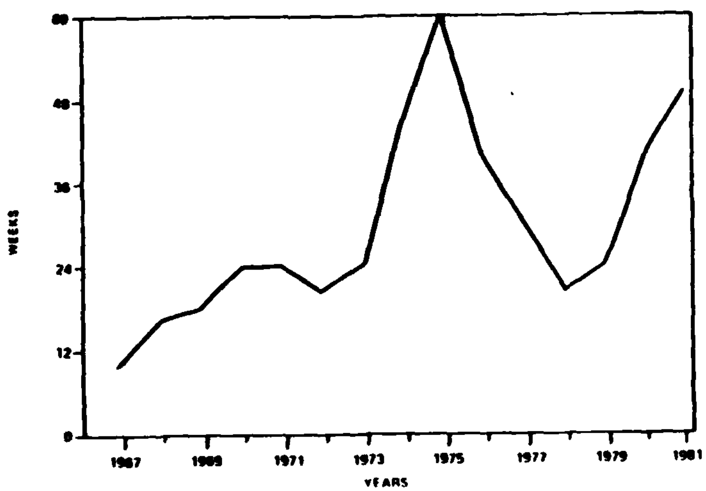

Figure E.2-23. Forgings, Steel, Large.

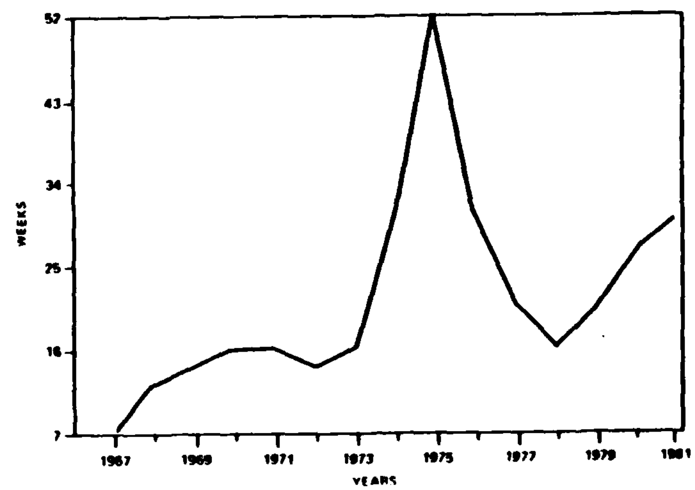

Figure E.2-24. Forgings, Steel Alloy, Small or Simple Shapes.

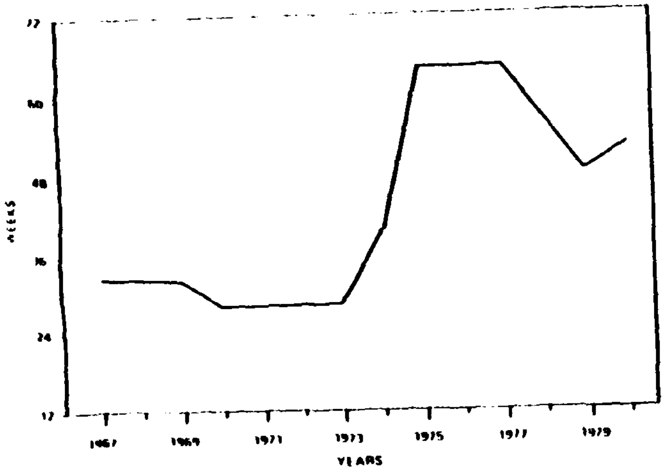

Figure E.2-25. Blower, Forced Draft, Port Use or Lighting Off, Motor Driven.

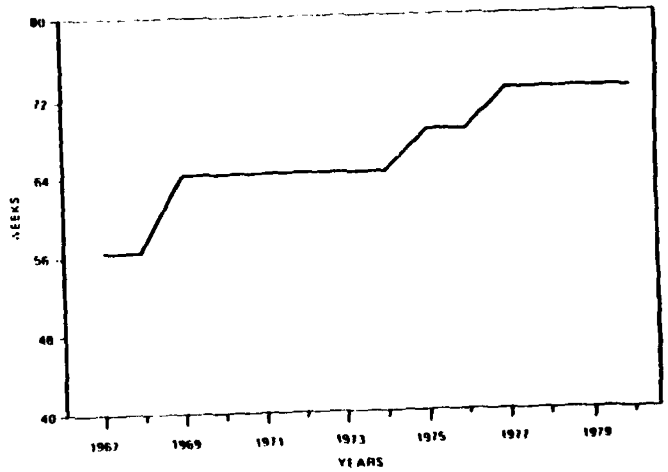

Figure E.2-26. Boiler, Auxiliary, Steam, Water Tube, MIL-B-16747 & MIL-B-17095.

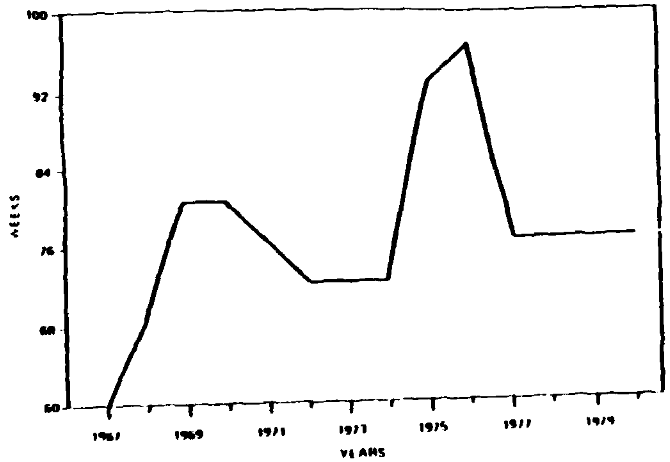

Figure E.2-27. Boiler, Main, Type 1-Natural Circulation, MIL-B-18381, 600 PSIG.

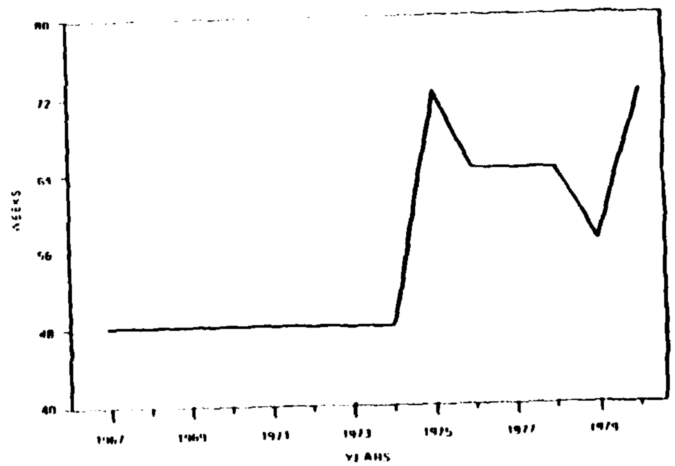

Figure E.2-28. Capstan, Power Driven, MIL-C-17944, Large & Medium Size.

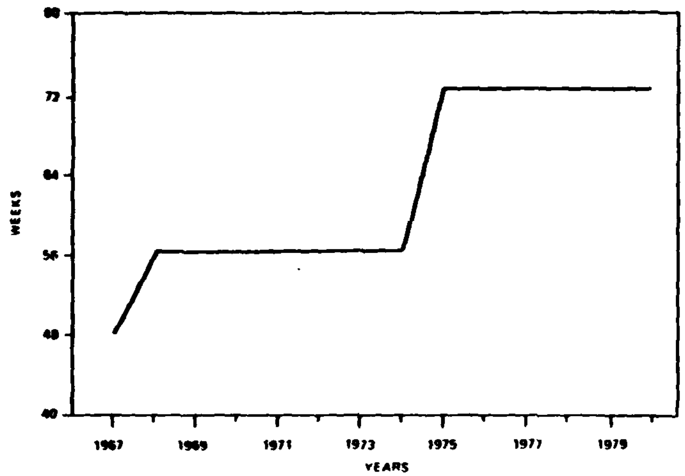

Figure E.2-29. Condenser, Auxiliary Type 3 & 4.

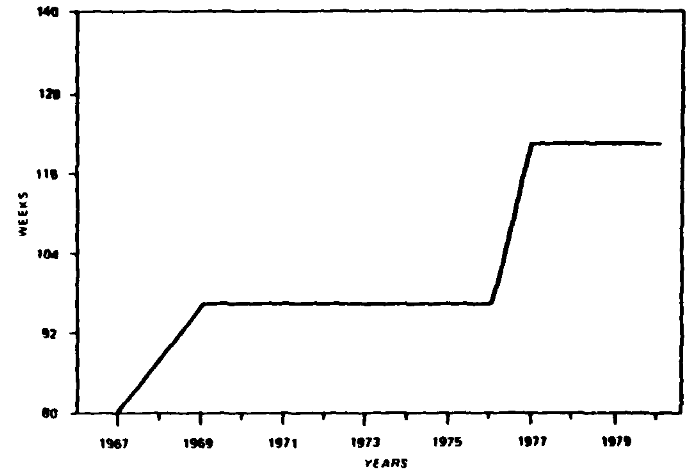

Figure E.2-30. Condenser, Steam Booster, MIL-C-15430, Main, Type 1, Nuclear.

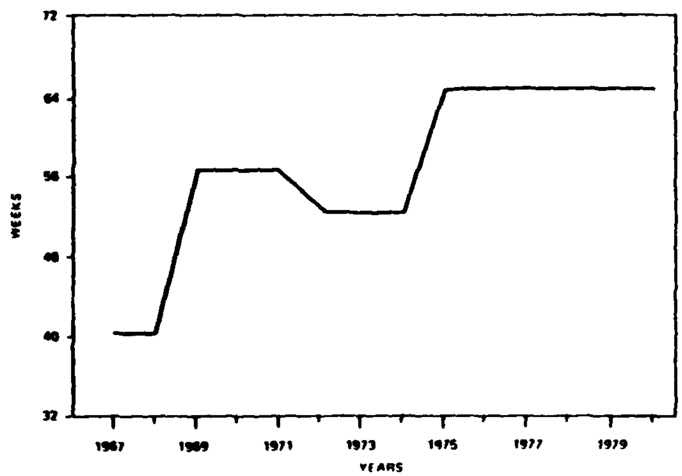

Figure E.2-31. Control Systems, Automated, Boiler, Feedwater.

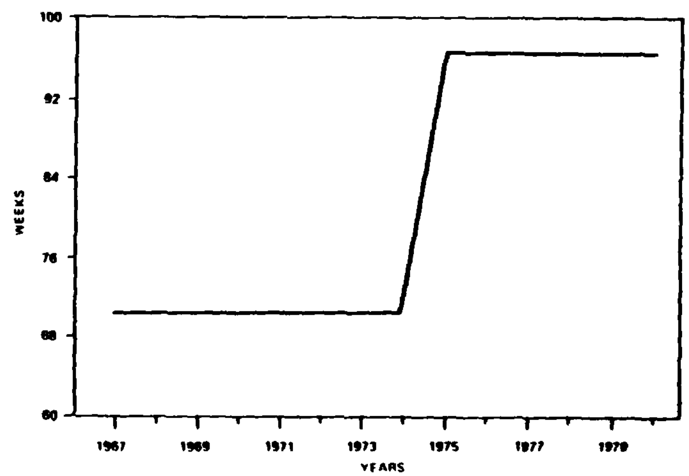

Figure E.2-32. Crane, Elector Hydraulic, MIL-C-17933.

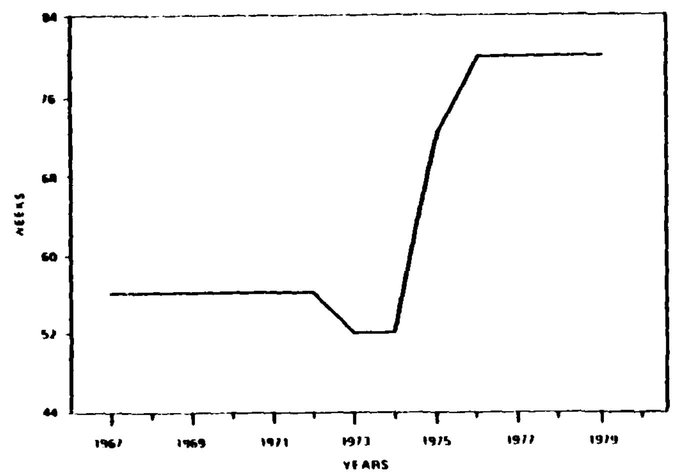

Figure E.2-33. Crane, Electronic, MIL-C-17949, Bridge.

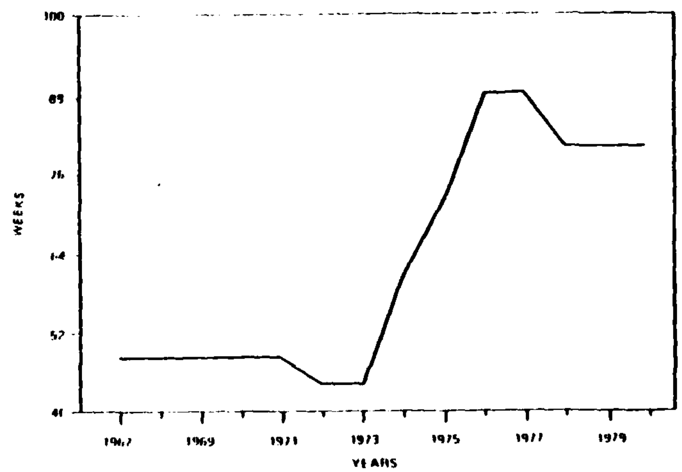

Figure E.2-34. Davit, Boat, Power Operated, MIL-D-17762.

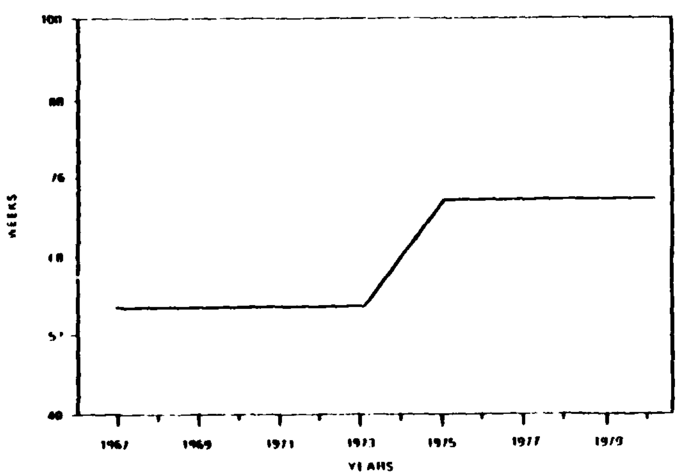

Figure E.2-35. Distilling Plant, Surface Ship, MIL-D-18641, 3500 thru 12000 GPD.

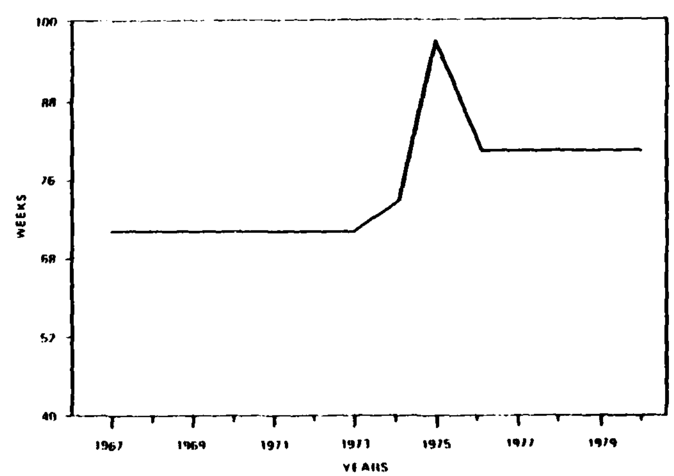

Figure E.2-36. Distilling Plant, Surface Ship, MIL-D-18641, over 12000 GPD.

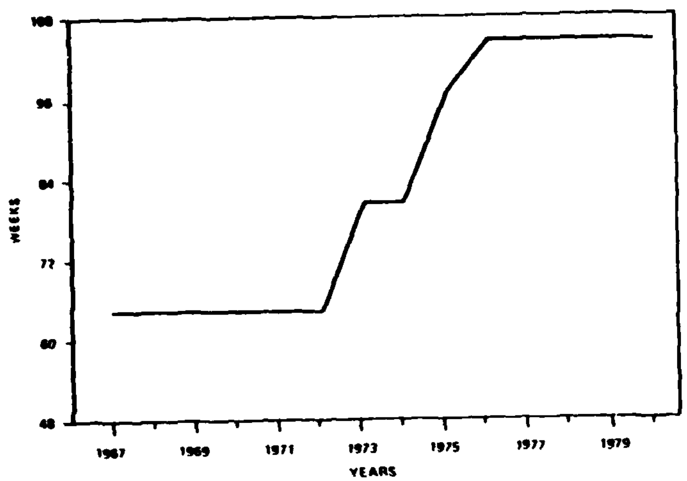

Figure E.2-37. Distilling Plant, Submarine, MIL-D-18541, MIL-D-16196.

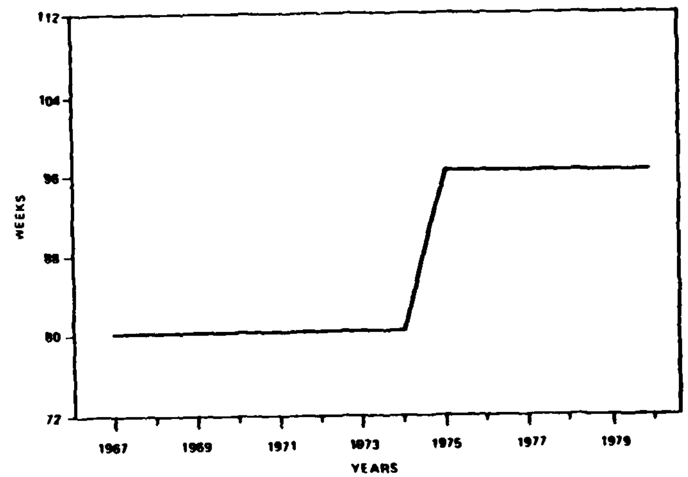

Figure E.2-38. Elevator Machinery, MIL-E-17007, Electro Hydraulic, 2 Point.

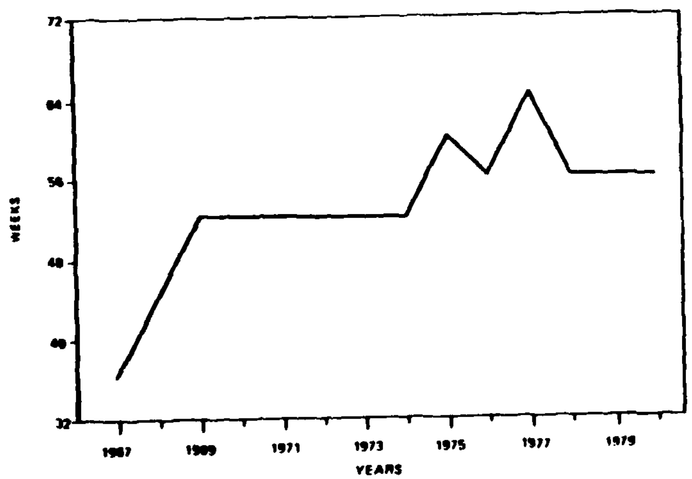

Figure E.2-39. Engine, Diesel, MIL-E-23457, Landing Craft, Above 300 BHP.

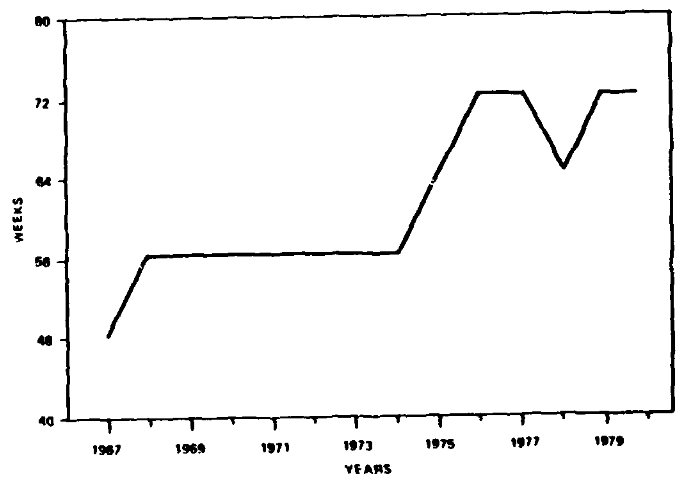

Figure E.2-40. Engine, Diesel, MIL-E-23457.

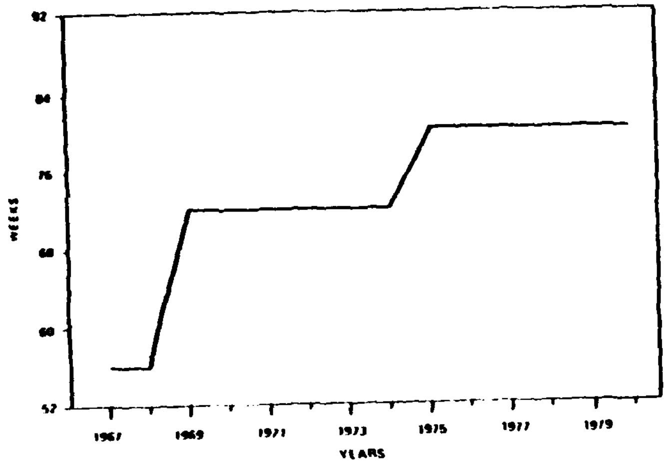

Figure E.2-41. Generator, Electric, Diesel Engine, Driven, AC or DC, Submarine Snorkel.

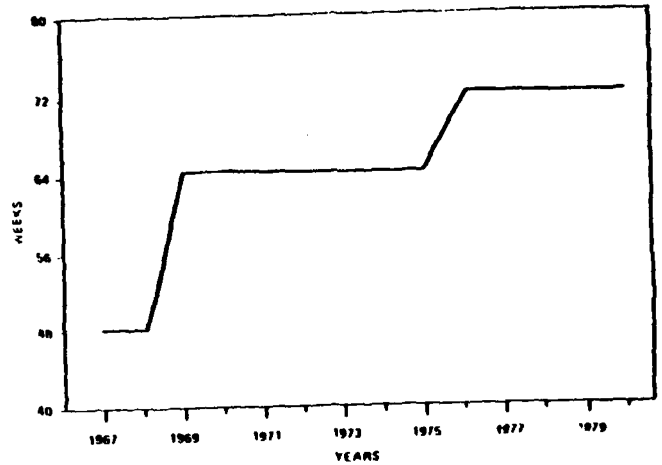

Figure E.2-42. Generator, Electric, Gas Turbine Driven, under 1000 KW.

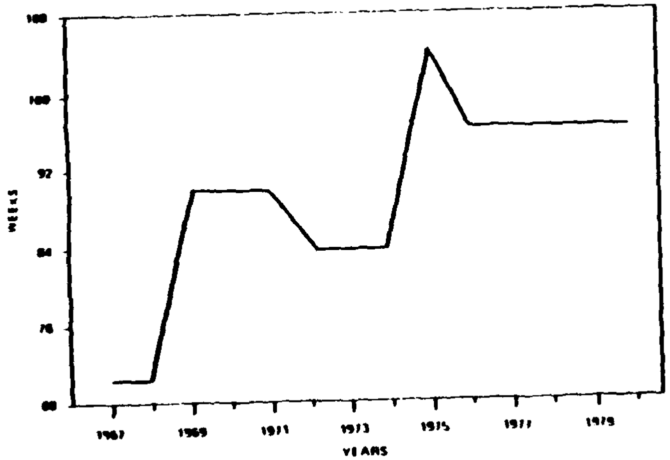

Figure E.2-43. Generator, Electric, Steam Turbine Driven, AC or DC.

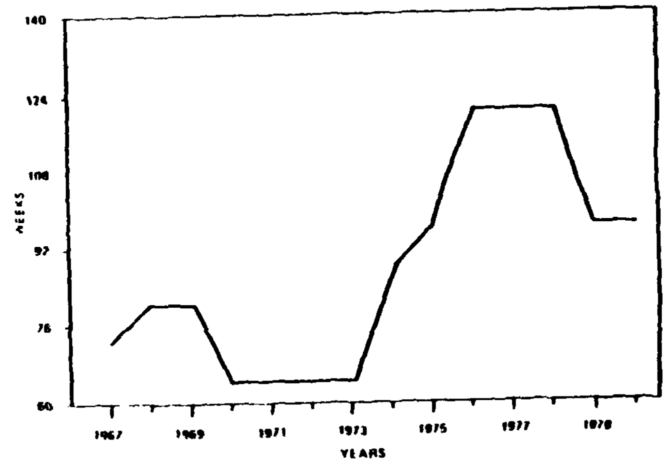

Figure E.2-44. Generator, Oxygen-Nitrogen.

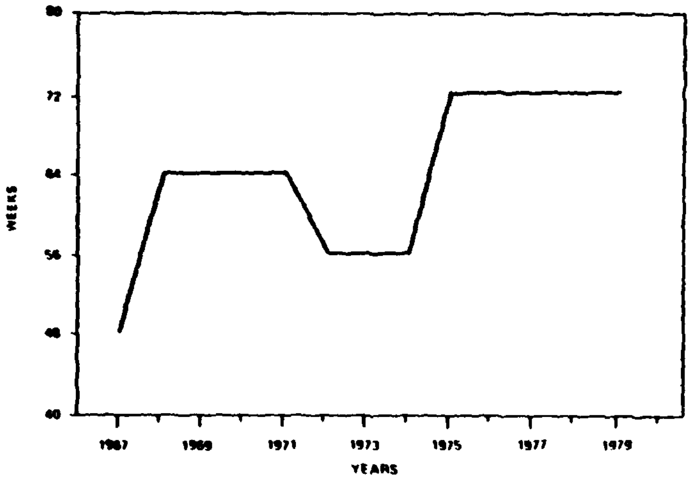

Figure E.2-45. Hoist, Bi-Rail Trolley, Electric, Missile Handling.

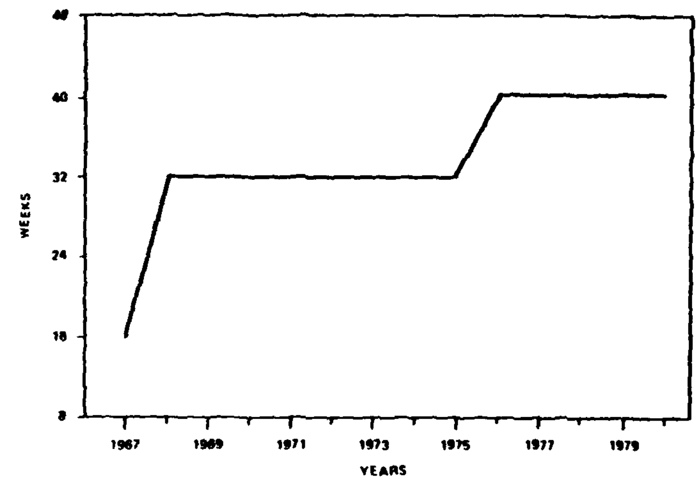

Figure E.2-46. Shafting, Propeller, Solid, Monel, Up to 3½" Diameter.

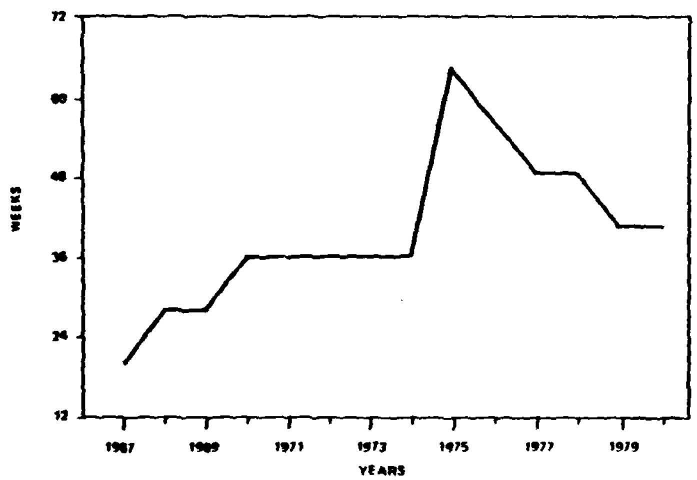

Figure E.2-47. Struts, Shaft, Steel, Large.

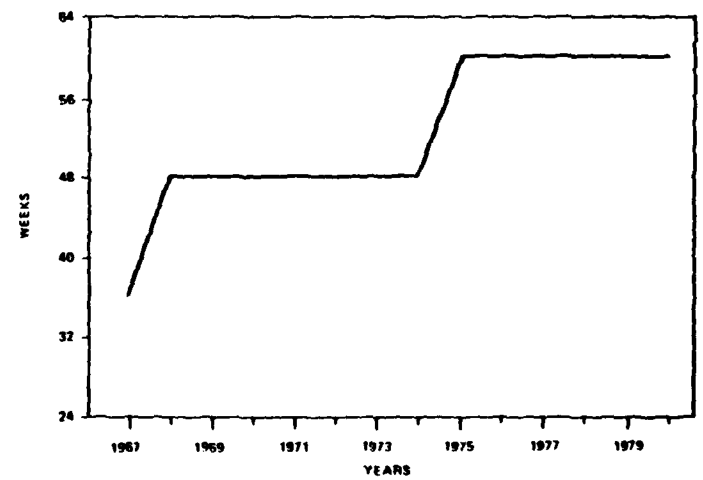

Figure E.2-48. Switchboards, Ships Power and Load Centers.

APPENDIX F

STUDY OBJECTIVES AND RESEARCH METHODOLOGY

1. BACKGROUND

Numerous sources both in and outside of the Department of Defense have observed or stated that the lead times for the acquisition of major weapon systems have been increasing at an alarming rate during the past decade. Unanticipated significant expansion of acquisition process times can and has resulted in notable problems in planning, programming, and budgeting not only for DoD Program Managers but for all cognizant service and DoD levels. These problems, translated into requirements for additional funding, in many cases have gone all the way to Congress. Similar type problems were also occurring in the private sector with various degrees of concern (see Section 3). Having recognized this, DoD has taken procedural action to alleviate some of the adverse effects attributed to longer lead times; however, these actions in most cases have addressed the symptoms rather than the causes of the problems. Recognizing the need to evaluate the causes of increasing lead times, the Defense Systems Management College (DSMC) proposed that such a study be conducted.

2. STUDY OBJECTIVES

Doty Associates, Inc. was awarded the study effort under Task Order 80-2, Contract MDA 903-80-C-0519, which commenced on 14 July 1980. The primary objectives of the study were to analyze and define the causes of long lead times, develop alternatives, and propose a recommended course of action. These latter two objectives were to be directed to two levels, those that could be considered within the purview of a Program Manager, and those that might be recommended for consideration by DoD.

3. RESEARCH METHODOLOGY

3.1 Research Tasks. The research effort was structured into four tasks, specifically, to:

- Identify, define, and classify items experiencing increasing lead times in major weapon system acquisitions,
- Determine, define, and classify causes of long lead items,

- Develop alternatives that could be considered by Program Managers and DoD for the possible improvement or alleviation of long lead time problems, and

- Recommend courses of actions for Program Managers and those that might be considered by DoD.

3.2. Research Approach. To identify items and causes of increasing lead times during the past decade, the research effort analyzed the environment of major weapon system acquisitions during the time frame 1965-1980 to determine if certain conditions or causes occurred in the late '60s and early '70s that might have caused or influenced the significant increases in lead times noted in the late '70s. Further, by selecting a broader time frame, rather than just the late '70s, it was anticipated that more opportunities would exist for obtaining data, thus providing a basis for developing lead time trends and possibly even forecasts.

The environment within which major weapon system acquisitions were taking place during the study time frame had to be defined so that potentially influencing factors such as those listed below could be identified and analyzed:

- legislative laws and decisions,
- in-house DoD acquisition guidance,
- other government regulations,
- the economic and business climate, and
- other considerations and influences.

In order to accomplish the above research, which also included the first two research tasks cited in Section F.3.1, a data collection was undertaken that encompassed an extensive literature search and interviews with personnel in DoD, other government departments and agencies, private industry including both prime and subcontractors, suppliers, and various associations.

3.3. Data Collection. Besides the data and information available in Doty Associates' Technical Library, significant acquisitions of qualitative and quantitative data were obtained through personnel contacts, interviews, and a variety of literature searches.

3.3.1. Contacts and Interviews. To develop an initial list of personnel to contact regarding relevant information and data, reviews of the following documents were made:

- DoD and Federal organization charts and telephone directories,
- various associations' membership directories, particularly those of the National Security Industrial Association (NSIA) and the American Defense Preparedness Association (ADPA),
- attendees lists at seminars on material and acquisition management, and
- the Thomas Register of American Manufacturers, 70th Edition, 1980.

As individuals identified on the initial list were contacted, they often suggested other individuals who were also contacted. Overall, 105 individuals in government (87 from DoD) and 40 individuals in the private sector contributed their time and effort to provide qualitative and/or quantitative information and data to this study. Contacts and interviews were conducted by telephone or in person with study team members utilizing two basic questionnaires, one for DoD and other government personnel and the other for the private sector. Team members would select or modify questions from the basic questionnaires depending on the position or field in which the contact or interviewee was involved, the person's responsiveness, time allotted or available for the interview, etc. In certain instances, only specific questions or requests for known information and/or data were made. A complete listing of contacts including offices, titles (if provided), and telephone numbers is provided in Tab F-1 of this Appendix.

3.3.2. Literature Searches. A variety of searches were employed to obtain information and data for the study. Custom searches were conducted of several large semi-automated and automated on-line bibliographic data bases such as:

- Defense Logistics Studies Information Exchange (DLSIE)
  - Logistics studies obtained from various government and nongovernment agencies,
- Defense Technical Information Center (DTIC)
  - DoD Technical studies and reports,

- Federal Legal Information Through Electronics (FLITE)
    - Armed Services Board of Contract Appeals Decisions,

- National Technical Information Center (NTIS)
    - Government sponsored research and development technical reports,

- ORBIT (a time-shared, on-line automated data base search services provided by the System Development Corporation)
    - Access was made to the following ORBIT data bases:
        - <u>CIS Data Base</u> - provided by the Congressional Information Service and covers publications emanating from the work of committees and subcommittees of the U.S. Congress from 1970 to the present.
        - <u>ASI Data Base</u> - also provided by the Congressional Information Service and covers serials, periodicals, and special publications containing economic, social, and demographic data collected by all branches and agencies of the U.S. Government from 1973 to the present.

In addition, card catalogs were reviewed at the following libraries:

- Defense Systems Management College (DSMC) Library,
- Industrial College of the Armed Forces (ICAF) Library,
- Army Library - Pentagon,
- National Bureau of Standards (NBS) Library,
- Department of Commerce Main Library,
- Federal Acquisition Institute Library, plus
- local public libraries.

Keyword search strategies were developed and used in all semi-automatic and automatic data base searches. The strategies were also selectively used during library card catalog reviews. Based on the keyword searches, several hundred citations and abstracts were reviewed, and resulted in the identification and evaluation of over 400 documents that were determined to be relevant to the study. As requested during the third Progress Briefing, the bibliography of this study contains only documents considered appropriate as references that would assist Program Managers (PMs) in broadening their knowledge regarding increasing lead times in major weapon systems acquisition. With regard to the study bibliography, it was decided to exclude relevant Defense Acquisition Regulations (DAR) citations, DoD Directives and Instructions, as well as specific military service department regulations,

manuals, instructions, and notices, as these would normally be available and accessible to any PM.

One of the causes that had been cited in a number of reports and interviews regarding the increase in lead times during the 1970s was the proliferation of DoD guidance regarding major weapon system acquisitions. It was stated that as a result of the guidance, justification efforts, reviews, and efforts to ensure that acquisition complied with the guidance had in fact slowed down the acquisition process. To evaluate this possible cause, a special research effort was conducted to identify the major DoD weapon systems acquisition guidance provided through memoranda, directives, and instructions during the period 1965 through 1980 for subsequent evaluation. Initial identification of guidance was based on Mr. David D. Acker's article on the maturing of the DoD acquisition process (Ref. 1) and DoD Instruction 5000.2, "Major System Acquisition Procedures," of 19 March 1980. Subsequently, the historical record files of the Assistant Secretary of Defense (Administration) (Ref. 2) were researched to construct the chronology of the DoD weapon systems acquisition guidance presented in Tab F-2 of this Appendix.

3.3.3. Quantitative Lead Time Data Sources. Most of the quantitative data regarding lead times was obtained from the following commands and activities:

- Joint Aeronautical Materials Activity (JAMAC), Wright-Patterson Air Force Base, Ohio,
- Materiel Development and Readiness Command (DARCOM) Headquarters, U.S. Army, Alexandria, Virginia, and
- Navy Shipbuilding Scheduling Office (NAVSHIPSO), Philadelphia Naval Shipyard, Philadelphia, Pennsylvania.

Although data was requested for the period 1965 through 1980, the above cited commands and activities provided the following:

- JAMAC - data from 1977 through 1980.
- DARCOM - data for 1979 and 1980.
- NAVSHIPSO - data from 1967 through 1980.

Various amounts of quantitative data were obtained through interviews and a number of recently produced reports such as General Slay's statement before the Industrial Preparedness Panel (Ref. 3), the report of the Defense Industrial Base Panel of the Committee on Armed Services on the ailing defense industrial base (Ref. 4), the Defense Science Board 1980 Summer Study on industrial responsiveness (Ref. 5), and a draft report of the Joint DARCOM/NMC/AFLC/AFSC Commanders (Ref. 6).

3.4. Data Analysis. Identification, definition, and classification of items and causes of increasing long lead times were accomplished through the analysis of the data collected as discussed above. This analysis completed the first two tasks of the research effort and established the basis for the completion of the last two research tasks of developing alternatives and recommending courses of action (see F.3.1 above). It was found that considerable data existed regarding lead times of items, particularly during recent years; however, it was noted that data cited in various reports were identical to or based on data provided by JAMAC and NAVSHIPSO, or only cited current lead times. Further, in a number of cases, nomenclatures for long lead items were either too generalized or too specific to be categorized for inclusion in the lead time trend analysis. In addition, when extreme variances in a specific item's lead time were noted in one report as compared with lead times in other reports, they were excluded from the trend analysis, and likewise, obvious errors such as lead times for an item that were consistently out of phase by a year were also excluded. Based on the trend analysis, trend charts of items identified as having significantly increasing long lead times were developed and are presented in Appendix E of this report. It should be noted that numerous items that were analyzed had either no increase or insignificant increasing trend lines, and therefore were not included in this report.

TAB F.1

STUDY CONTACTS AND INTERVIEWS LISTING

Over 200 individuals were contacted by telephone or in person for interviews or specific information relevant to this study. Of those contacted, 145 individuals listed in the following two tables contributed qualitative and/or quantitative information and data to the study. Accordingly, their names are listed for reference and recognition of their assistance. Table F.1-1 lists 105 individuals in government, 87 of whom were in the Department of Defense, and Table F.1-2 lists 40 individuals in the private sector.

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
Congress	Committee on Gov't Operations	House of Reps.	Staff Analyst	Mr. James Lewin	202/225-5051
DoD	Assistant Secretary of Defense (Comptroller)	Management Systems	Director, Data Automation	Mr. John Carabello	202/697-8580
DoD	Assistant Secretary of Defense (MRA&L)	Assistant Secretary for Manpower, Reserve Affairs and Logistics	Assistant Secretary (MRA&L)	Hon. Robert Pirie, Jr.	202/695-5254
DoD	Undersecretary for Policy	Acquisition Policy	Deputy Director for Major Systems Acquisition	Mr. John Smith	202/695-2400
DoD	Undersecretary for Policy	International Economic Affairs	Deputy Assistant Secretary	Dr. Ellen L. Frost	202/697-5334
DoD	Undersecretary for Policy	International Economic Affairs		Mr. Carl Groth	202/697-1802
DoD	Undersecretary for Policy	International Economic Affairs	Technology and Arms Transfer Policy	Col. James Kingston	202/695-9282
DoD	Undersecretary for Research & Engineering	Acquisition Policy	Chairman Defense Acquisition Regulatory System Committee	Mr. Charles Lloyd	202/697-6710
DoD	Undersecretary for Research & Engineering	Acquisition Policy	Director of International Acquisition	Col. Ronald Carlberg	202/697-9351

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
DoD	Undersecretary for Research & Engineering	Acquisition Policy	Federal Acquisition Regulation Project Manager	Col. Slenkard	202/695-5016
DoD	Defense Logistics Agency (DLA)		Chief DLA ADPE Replacement Program Office	Mr. Kurt Molholm	202/274-7523
DoD	Defense Logistics Agency	Contract Administration Services, Industrial Preparedness Planning		Mr. Nelson Thomas	202/274-6451
DoD	Defense Logistics Agency	Defense Contract Administration Services Mgmt. Area	Central Production Operations Branch Chief	Mr. Harold Goodin	202/427-5046
DoD	Defense Logistics Agency	Plans, Programs & Systems		Mr. Yenkovick	202/274-6315
DoD	Defense Logistics Agency	Plans, Programs & Systems	Plans & Policy	Mr. John Duke	202/274-6321
DoD	Defense Logistics Agency	Production	Chief of Industrial Resources and Preparedness Planning Division	Mr. Walter Groome	202/274-7764
DoD	Defense Logistics Agency	Production		Mr. Roger Roy	202/274-7544

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
DoD	Defense Logistics Agency	Production		Mr. Robert Askew	202/274-7651
DoD	Defense Logistics Agency	Supply Operations	Logistics Programs Office	Ms. Mary Ellen Harvey	202/274-6097
DoD	Defense Systems Management College (DSMC)		Industrial Chair	Mr. Charles George	202/664-4662
DoD	Army	Advanced Attack Helicopter Project Office	Program Manager	Maj. Gen. Edward M. Browne	314/263-1937
DoD	Army	Army Materiel Development and Readiness Command, Management Information Office	Scientific Application Branch	Mr. Aldric Saucier	202/274-8949
DoD	Army	Army Materiel Development and Readiness Command, Management Information Systems (MIS)	Materiel Development Systems	Mr. Solfie	202/274-8946
DoD	Army	Army Materiel Development and Readiness Command, Materiel Mgmt.	Associate Director Materiel Programs	Mr. Heinbach	202/274-8041

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
DoD	Army	Army Materiel Development and Readiness Command, Procurement & Production	Action Officer Associate Director Industrial Base Procurement & Production	Mr. Clark Winner	202/274-8200
DoD	Army	Army Material Development and Readiness Command, Procurement & Production	Deputy Director of Procurement & Production	Mr. George Dausman	202/274-8167
DoD	Army	Army Procurement Research, Ft. Lee	Director	Mr. Paul Arvis Mr. Robert Williams	804/734-3300
DoD	Army	Defense Logistics Studies Information Exchange (DLSIE) (Fort Lee)		Mr. J. Dowling	804/734-4255
DoD	Army	Deputy Chief of Staff for Research, Development, and Acquisition	Combat Support Systems	Maj. Syndek	202/697-0387
DoD	Army	Deputy Chief of Staff for Research, Development, and Acquisition	Weapon Systems Directorate	Mr. Miller	202/694-8720
DoD	Army	120 MM Gun Project Office	Assistant Project Manager	Col. Mehrtens	201/328-5460

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
DoD	Army	PLARS Project Office	Assistant Project Manager, Logistics	Maj. Boggess	201/532-5116
DoD	Army	Research, Development, and Acquisition (SARDA)	Deputy for Aviation Communications and Electronics	Mr. Robert Stohlman	202/695-5557
DoD	Army	Secretary of the Army, Research, Development, & Acquisition (SARDA)	Materiel Acquisition DEP	Ms. Sally Clements	202/695-2488
oD	Army	U.S. Armament Materiel Readiness Command	Acting Deputy for Procurement and Production	Mr. H. James Spangler	309/794-3823
DoD	Army	U.S. Army Missile Command, U.S. ROLAND Project Off.	Acting Deputy Project Manager	Col. Byron L. Power	205/876-2151
DoD	Army	XM1 Tank System	Chief XM1 Facilitization Task Force	LTC Wm. H. Pentz, Jr.	313/573-2284
DoD	Air Force	Air Force Systems Command	F-15, A-10, & Propulsion Division (SDTS)	Maj. William Eddy	202/981-5171
DoD	Air Force	Air Force Systems Command	Radar and Defense System Division (SDED)	Mr. Sherman Krasney	202/981-7485

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
DoD	Air Force	Air Force Systems Command, Contracting & Manufacturing	Chief, Plans & Management Office	Col. D. L. Debus Mr. Leo Baca	202/981-3368 202/981-4702
DoD	Air Force	Air Force Systems Command, Contracting & Manufacturing	Executive Officer	Lt. Col. Hardin	202/981-5991
DoD	Air Force	Air Force Systems Command, Development Plans (XR)		Col. Marshall	202/981-5525
DoD	Air Force	Air Force Systems Command, Directorate of Manufacturing (Andrews AFB)		Mr. Joseph Anderson	202/981-5991
DoD	Air Force	Air Force Systems Command (AFSC), Directorate of Manufacturing (Wright-Patterson AFB)	Industrial Materials Division Joint Aeronautical Materials Activity (JAMAC)	Mr. Lowell Horseman Mr. Wallace Wetterling	513/255-3701
DoD	Air Force	Air Force Systems Command, Production Management Division (Andrews AFB)		Maj. P. Giusti	202/981-7291
DoD	Air Force	E-4 Project Office	Chief Engineer	Mr. Paul A. Zielie	617/271-2738

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
DoD	Air Force	Deputy Chief of Staff for Logistics and Engineering, Maintenance & Supply (LEY)	Acquisition for Ammunition Combat Programs	Lt.Col. John J. Frost	202/695-1281
DoD	Air Force	Deputy Chief of Staff for Logistics and Engineering, Maintenance and Supply Directorate (LEY)	Aircraft Systems	Col. Bruin	202/695-4872
DoD	Air Force	Deputy Chief of Staff for Logistics and Engineering, Maintenance & Supply (LEY)	Munitions & Missiles	Col. John Cormier	202/695-4300
DoD	Air Force	Directorate of Strategic Aeronautical & Support Systems	Strategic Aeronautical Systems Division (SDNI)	Capt. Randy Sutter	202/981-3248
DoD	Air Force	Directorate of Tactical Aeronautical Systems	F-16, A-10 & Propulsion Division (SDTS)	Maj. Clyde Spell	202/981-5171
DoD	Air Force	C 5-A Mod. Project Office	Production Planning	Mr. George Aday	513/255-6607

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
DoD	Air Force	Secretary of the Air Force, Research, Development, and Logistics (SAFAL)	Procurement Deputy	Col. David Herfel	202/645-6351
DoD	Air Force	Secretary of the Air Force, Research, Development, and Logistics (SAFAL)	Assistant for Industrial Resources	Mr. Martin Rogers	202/647-1140
DoD	Air Force	Space & Ballistic Missile Directorate	Defense Satellite Communications System (SDSS)	Maj. Richard Smart	202/981-3194
DoD	Navy	NAVAIR	Assistant Director, Logistics Management (0410)	Mr. C. C. McClelland	202/692-0045
DoD	Navy	NAVAIR	Director, Missile Weapons System, Purchase Division (216)	Mr. Robt. N. Donatuti	202/692-1712
DoD	Navy	NAVAIR	Executive Director for Acquisition Management (05A)	Dr. A. J. DiMascio	202/692-8882
DoD	Navy	NAVAIR	516 Director - Engr. Support Management Division	Mr. Frederick J. Paul	202/692-7694

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
DoD	Navy	NAVAIR	Project Manager F-18, PMA 265	Capt. J. C. Weaver	202/692-7954
DoD	Navy	NAVAIR	PMA/PMS-266B Business/Finance Officer - LAMPS Project	CDR Richard Treanor	202/692-1368
DoD	Navy	NAVAIR, Contracts	AV-8 Project Contracting Officer	Mr. R. Rumberger	202/692-8030
DoD	Navy	NAVAIR, Contracts	E-2-ADTS Project Contracting Officer	Mr. Wm. A. John	202/692-0939
DoD	Navy	NAVAIR, Logistics	04B, Executive Director, Logistics	Capt. G. H. Strohsahl	202/692-2692
DoD	Navy	NAVAIR, Plans & Programs	Assistant Deputy CDR	Capt. Paul. B. Tuzo	202/692-2281
DoD	Navy	NAVAIR, Production Management Division		Mr. R. Bussler	202/692-7696
DoD	Navy	NAVAIR, Production Management Division, Industrial Preparedness Planning		Mr. Tony Gentilcore	202/433-3511
DoD	Navy	NAVAIR, Systems & Engineering	Armament Systems AIR 541	Capt. L. E. Kaufman	202/692-3792

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
DoD	Navy	NAVAIR, Systems & Engineering	Core Avionics	CDR Wm. Smith	202/692-3965
DoD	Navy	NAVAIR, Systems & Engineering	Director, Production Management 514	Capt. Larry Kunkel	202/692-2850
DoD	Navy	NAVAIR, Systems & Engineering	Product Integrity Management	Capt. R. H. Jones	202/692-7694
DoD	Navy	NAVMAT	Acquisition Logistics (0421)	Mr. E. Cale	202/692-3011
DoD	Navy	NAVMAT	Acting Head of Production Management Division (08D3)	Mr. P. A. Buck	202/692-5884
DoD	Navy	NAVMAT	ADCNM	Capt. F. P. Hueba	202/692-5884
DoD	Navy	NAVMAT, Acquisition Logistics	ADCNM	Capt. Wm. J. Smith	202/692-3013
DoD	Navy	NAVMAT, Logistics	Aviation Readiness & Support, Aircraft Support 0451	Capt. P. Johnson	202/692-1375
DoD	Navy	NAVMAT, Logistics	Plans & Programs	Mr. Robert Hallmark	202/692-7925
DoD	Navy	NAVMAT, Logistics	Test & Monitoring Systems P.O.	Capt. A. J. Tenefrancia	202/692-2035

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
DoD	Navy	NAVMAT, Production Management Division	ADCNM for Acquisition Control	Mr. P. C. Buck	202/692-8664
DoD	Navy	NAVSEA, Acquisition Control Division	SEA 901	Mr. John Parker	202/692-3111
DoD	Navy	NAVSEA, Facilities & Equipment Division	SEA 713	Mr. K. Harris Mr. A. Bailey	202/692-9199
DoD	Navy	NAVSEA, NAVSHIPSO Philadelphia		Mr. M. Marziano	215/755-3520
DoD	Navy	NAVSEA, NAVSHIPSO (Shipbldg. Sched. Office)	2960	Mr. C. W. Lafferty	215/755-3520 -3161
DoD	Navy	Office Assistant Secretary of the Navy (RE&S)	Principal Deputy Assistant Secretary	Mr. Gerald Cann	202/697-4928
DoD	Navy	Office Assistant Secretary of the Navy, Research and Development (OASN, R&D)	Integrated Vehicle Systems Spec. Asst.	Mr. Peter Mantle	202/694-4480
Federal Emergency Management Agency	Evaluation Systems Branch	Operations Support	Chief	Mr. Bob Wilson	202/653-7718

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
Federal Emergency Management Agency	Research & Mitigation		Economist	Mr. George Divine	202/653-7841
Federal Emergency Management Agency	Resources Preparedness Office	Stockpile Policy Division	Commodity Industry Analyst	Mr. Bob Mroczek	202/566-0800
Interior	Bureau of Mines	Branch of Domestic Data	Economist Minerals & Materials Publication	Mr. Kent Hanks	202/653-7739
Interior	Bureau of Mines	Branch of Domestic Data, Ferrous Metals Section	Commodity Specialist for Chromium	Mr. Edward C. Peterson	202/634-1020
Interior	Bureau of Mines	Branch of Domestic Data, Ferrous Metals Section	Commodity Specialist for Cobalt	Mr. John Kummer	202/634-1025
Interior	Bureau of Mines	Branch of Domestic Data, Ferrous Metals Section	Commodity Specialist for Iron and Steel	Mr. Donald H. Desy	202/634-1022
Interior	Bureau of Mines	Branch of Domestic Data, Ferrous Metals Section	Commodity Specialist for Nickel	Mr. Scott F. Sibley	202/634-1025

TABLE F.1-1. LONG LEAD TIME STUDY
GOVERNMENT CONTACTS AND INTERVIEWS (continued)

DEPARTMENT	AGENCY/ SERVICE	OFFICE/ COMMAND	CONTACT/ INTERVIEWEE TITLE/CODE	CONTACT/ INTERVIEWEE NAME	TELEPHONE NUMBER
Interior	Bureau of Mines	Branch of Domestic Data, Ferrous Metals Section	Commodity Specialist for Tantalum	Mr. Thomas S. Jones	202/634-7091
Interior	Bureau of Mines	Branch of Domestic Data, Nonferrous Metals Section	Commodity Specialist for Aluminum	Dr. Horace F. Kurtz	202/634-1080
Interior	Bureau of Mines	Branch of Domestic Data, Nonferrous Metals Section	Commodity Specialist for Beryllium, Magnesium, and Magnesium Compounds	Mr. Benjamin Petkof	202/634-1073
Interior	Bureau of Mines	Branch of Domestic Data, Nonferrous Metals Section	Commodity Specialist for Germanium	Ms. Patricia Plunkert	202/634-1063
Interior	Bureau of Mines	Branch of Domestic Data, Nonferrous Metals Section	Commodity Specialist for Platinum Group Metals	Ms. Christine Moore	202/634-1053
Interior	Bureau of Mines	Branch of Domestic Data, Nonferrous Metals Section	Commodity Specialist for Titanium	Mr. Langtry E. Lynd	202/634-1073
Interior	Bureau of Mines	Branch of Domestic Data, Nonmetallic Minerals Section	Commodity Specialist for Asbestos	Mr. Robert A. Clifton	202/634-1206
Interior	Bureau of Mines	Branch of Domestic Data, Nonmetallic Metals Section	Commodity Specialist for Mica	Mr. Alvin Zlobik	202/634-11[illegible]

TABLE F.1-2. LONG LEAD TIME STUDY
PRIVATE SECTOR CONTACTS AND INTERVIEWS

COMPANY/ ASSOCIATION	CONTACT/INTERVIEWEE POSITION	CONTACT/INTERVIEWEE NAME	TELEPHONE NUMBER
Aerospace Industries Assoc. of America Washington, D.C.	Executive Secretary, Materiel Mgmt. Committee	Mr. John D. Geron	202/347-2315
Aircraft Supplies Co. Clifton, N.J.	Sales	Mr. Jim Williamson	201/778-9100
Alcoa Washington, D.C.	Government Sales	Mr. Gregory Barthold	202/313-2000
American Foundryman's Society Des Plaines, Ill.	Vice President Technology	Mr. Mervin Rauley	312/824-0181
The Analytic Sciences Corporation Washington, D.C.	Vice President	Dr. Jacques Gansler Ms. Judith Larabee	202/558-7417
Anti-Friction Bearing Manufacturer's Association Arlington, Va.	President	Mr. James Whitsett	703/979-1261
Armed Forces Communications and Electronics Association Falls Church, Va.	Director of Corporate Affairs	Mr. Kirby Lamar	212/820-5028
Bird-Johnson Co. Walpole, Mass.	Government Program Manager	Mr. Andrew Bars	617/668-9610
Boeing Aerospace Seattle, Wash.	Director of Contracts	Mr. W. S. Lambert	206/931-2280

TABLE F.1-2. LONG LEAD TIME STUDY
PRIVATE SECTOR CONTACTS AND INTERVIEWS (continued)

COMPANY/ ASSOCIATION	CONTACT/INTERVIEWEE POSITION	CONTACT/INTERVIEWEE NAME	TELEPHONE NUMBER
Boeing Vertol Company Philadelphia, Penn.	Unit Chief in Purchasing	Mr. Raymond Van Ness	215/522-3884
Cast Metals Federation Washington, D.C.	Vice President for Government Affairs	Mr. Walter Kiplinger	202/833-1316
Fafnir Bearing Division of Textron, Inc. New Britain, Conn.	Military Contracts Division	Mr. Peter Hopkins	203/225-5151
Fansteel Inc. North Chicago, Ill.	Sales	Mr. Jerry O'Grady	312/689-4900
Forging Industry Association Cleveland, Ohio	Director of Gov't Affairs	Mr. R. W. Wickstrom	216/781-6260
Foundry Magazine Cleveland, Ohio	Marketing Manager Research Department	Mr. James Forthofer	216/696-7000
General Dynamics St. Louis, Mo.	Corporate Manager, Procurement	Mr. James Martini	314/862-2440
General Electric Aircraft Engine Group Lynn, Mass.	Manager Business Plans and Practices	Mr. Ralph S. Rubenstein	617/594-0100 Ext. 2269
General Electric Boston, Mass.	Manager F 404 Production Program	Mr. Carrie Kotar	617/594-5285
General Electric Company Washington, D.C.	Manager, Aerospace Field Operations	Mr. Phillip Luttenberger	202/637-4243

TABLE F.1-2. LONG LEAD TIME STUDY
PRIVATE SECTOR CONTACTS AND INTERVIEWS (continued)

COMPANY/ ASSOCIATION	CONTACT/INTERVIEWEE POSITION	CONTACT/INTERVIEWEE NAME	TELEPHONE NUMBER
General Electric Co. (cont'd)	Program General Manager, Washington Area Programs	Mr. Phillip Ierardi	202/637-4181
Harris Corp Harris Controls Division Melbourne, Fla.	Director of Administration	Mr. Richard Petit	305/727-5020
Honeywell Defense Sys. Div. Hopkins, Minn.	Procurement Manager	Mr. Robert Specht	612/931-5529
Ladish Company Cudahy, Wisc.	Sales Engineer	Mr. Norman Mullanger	414/747-2611
	Vice President and Manager Cudahy Forgings Division Sales	Mr. Ralph Starz	414/747-2680
Lockheed Missiles & Space Co. Sunnyvale, Calif.	Materiel Director	Mr. Morgan McGilvray	408/742-3232
McDonnell-Douglas Astronautics Company St. Louis, Mo.	Vice President	Mr. James Duez	202/638-1047 Ext. 27129
MRC Bearings Jamestown, N.Y.	Account Representative Engineering	Ms. Sandra Christ Mr. Charles Morris	716/661-2600 716/661-2819
Oregon Metallurgical Corp. Albany, Or.	Chief Accountant	Mr. Chris Erickson	503/926-4281 800/547-4101

TABLE F.1-2. LONG LEAD TIME STUDY
PRIVATE SECTOR CONTACTS AND INTERVIEWS (continued)

COMPANY/ ASSOCIATION	CONTACT/INTERVIEWEE POSITION	CONTACT/INTERVIEWEE NAME	TELEPHONE NUMBER
Pratt & Whitney Washington, D.C.	Vice President	Mr. Eugene J. Tallia	202/785-7427
Raytheon Company Lexington, Mass.	Procurement Specialist	Mr. Daniel Burke	617/862-6600
Rexnord Inc. Milwaukee, Wisc.	Senior Sales Analyst	Mr. Preston Beckley	414/643-3000
Rockwell International Dallas, Tex.	Director of Materials	Mr. James Kerr	214/996-7990
Teledyne Microelectronics Los Angeles, Calif.	Director of Business Development	Mr. Court Parkinson	213/822-8229
Timkin Roller Bearings Fort Washington, Penn.	District Manager Industrial Division	Mr. Paul T. Malone	215/643-4970
Todd Shipyards New York, N.Y.	Assistant to the President	Mr. Joseph Kochanczyk	212/344-6900
TRW Cleveland, Ohio	Vice President for Technical Resources	Dr. Arden Bement	216/383-2992
Watkins-Johnson Gaithersburg, Md.	Manager of Customer Applications Engineering	Mr. John Gearing	301/948-7550
Wyman-Gordon Worcester, Mass.	Manager of Marketing Administration	Mr. James Corey	617/839-4441

TAB F.2

MAJOR DOD WEAPON SYSTEMS ACQUISITION GUIDANCE

PUBLISHED DURING THE PERIOD 1965-1980

One of the significant causes of increasing long lead times, as cited in numerous reports, articles, and interviews with DoD and private industry personnel, has been the impact of implementing DoD policy guidance for weapon systems acquisition. The impacts have ranged from increased review levels within DoD, through which a Program Manager must "sell his program," to increased requirements on private industry to conform to specific accounting and performance reporting systems, as well as other documentation needs not normally required by the business community.

Figure F.2-1 and Tables F.2-1 and F.2-2 illustrate only the major DoD weapon systems acquisition guidance issued, revised, and updated from 1965 through 1980. In addition, many revisions were accomplished through change notices or incorporated into other directives. According to DoD Instruction 5000.2, "Major System Acquisition Procedures" of 19 March 1980, there are well over one hundred twenty (120) DoD directives and instructions applicable to major weapon systems acquisition, and these do not even include the guidance in the Defense Acquisition Regulations (DAR).

Table F.2-1 is a chronology by year, and Table F.2-2 is grouped in directive or instruction number sequence to illustrate the number and frequency of revisions and reissues of the guidance documentation. In Table F.2-2, it can be noted through subject titles that some guidance documentation migrated from one number sequence to another, and even changed from directives to instructions. In addition, several Secretary of Defense (SECDEF) and Deputy Secretary of Defense (DEPSECDEF) memoranda have been included, since the memoranda were highly significant in the establishment of the weapon systems acquisition guidance of the 1980s (References 1, 2, and 3).

AD-A113 459 DOTY ASSOCIATES INC ROCKVILLE MD F/G 15/5
STUDY OF INCREASING LEAD TIMES IN MAJOR WEAPON SYSTEMS ACQUISIT--ETC(U)
JUL 82 W B HUMPHREY, R B LADD, J N POSTAK MDA903-80-C-0519
UNCLASSIFIED DAI-TR-254 NL

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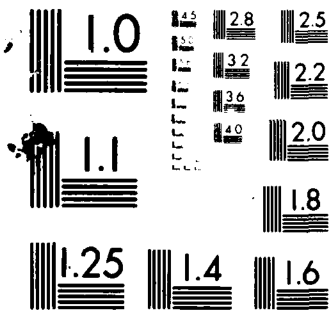

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

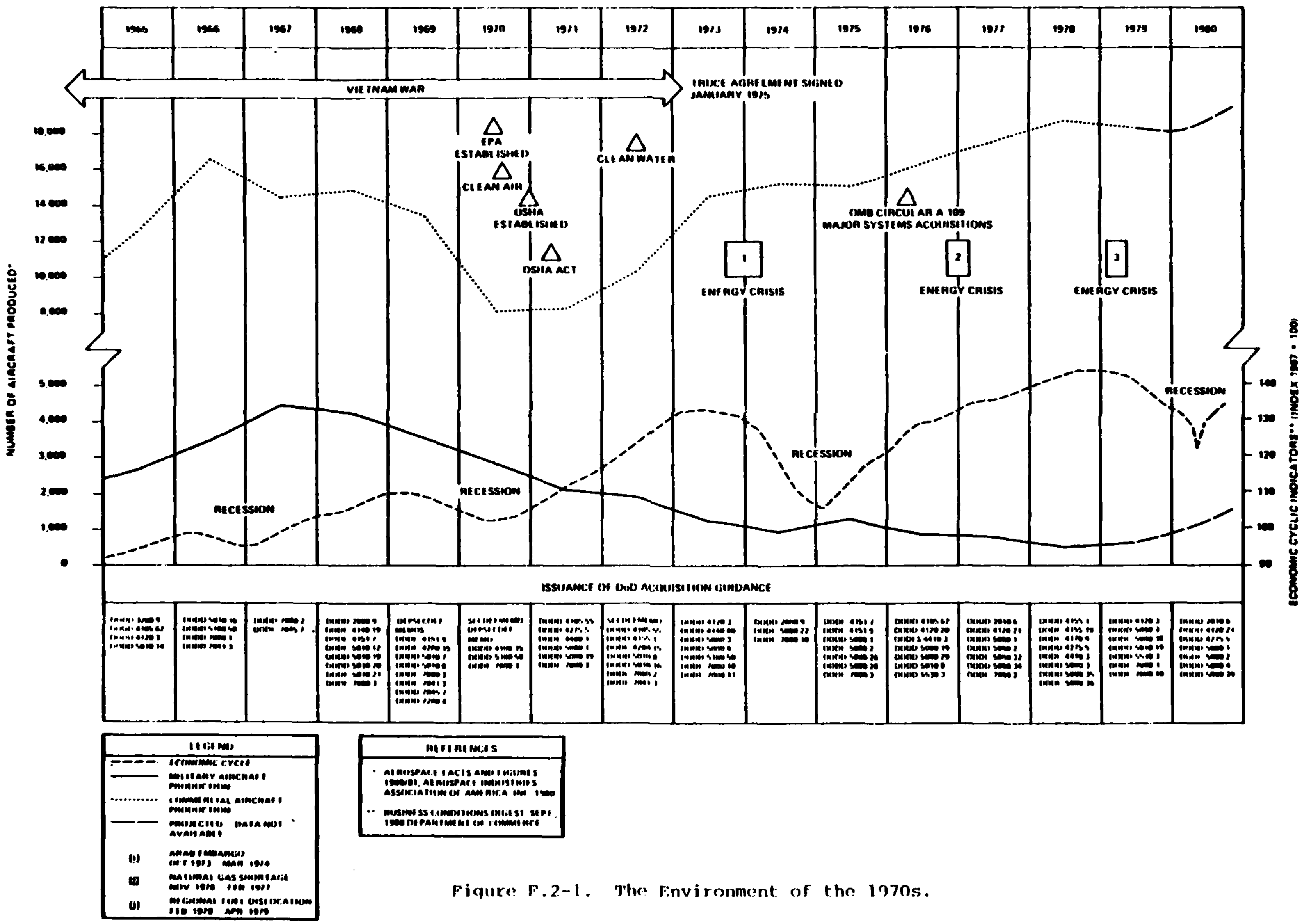

Figure F.2-1. The Environment of the 1970s.

TABLE F.2-1. DOD GUIDANCE CHRONOLOGY

DATE	ITEM NUMBER	TITLE
6 Apr. 1965	DODD 4105.62	Proposal Evaluation and Source Selection
23 Apr. 1965	DODD 4120.3	Defense Standardization Program
4 May 1965	DODD 5010.14	System/Project Management
1 Jul. 1965	DODD 3200.9	Initiation of Engineering and Operational Systems Development
4 Jan. 1966	DODD 5100.50	Environmental Pollution Control
22 Aug. 1966	DODD 7000.1	Resource Management Systems of the Department of Defense
12 Sep. 1966	DODD 5010.16	Defense Management Education and Training Program
19 Dec. 1966	DODI 7041.3	Economic Analysis of Proposed Department of Defense Investments
22 Dec. 1967	DODD 7000.2	Performance Measurement for Selected Acquisitions
22 Dec. 1967	DODI 7045.7	Review and Approval of Changes to the Five Year Defense Program
28 Feb. 1968	DODI 7000.3	Selected Acquisition Report (SAR)
26 Mar. 1968	DODD 2000.9	International Coproduction Projects and Agreements Between the U.S. and Other Countries or International Organizations
1 May 1968	DODI 4140.19	Phased Provisioning of Selected Items for Initial Support of Weapons Systems, Support Systems, and End Items of Equipment
17 Jul. 1968	DODD 5010.19	Configuration Management
31 Jul. 1968	DODD 5010.20	Work Breakdown Structures for Defense Materiel Items

TABLE F.2-1. DOD GUIDANCE CHRONOLOGY (continued)

DATE	ITEM NUMBER	TITLE
6 Aug. 1968	DODI 5010.21	Configuration Management Implementation Guidance
5 Dec. 1968	DODI 4151.7	Management of Technical Data
5 Dec. 1968	DODI 5010.12	Management of Technical Data
24 Jan. 1969	DODI 4151.9	Technical Manual Management
30 Jan. 1969	DODI 4200.15	Manufacturing Technology Program
26 Feb. 1969	DODI 7041.3	Economic Analysis of Proposed Department of Defense Investments
29 May 1969	DODD 5010.7	DOD Value Engineering Program
30 May 1969	DEPSECDEF Memo	Establishment of a Defense Systems Acquisition Review Council
31 Jul. 1969	DEPSECDEF Memo	Improvement in Weapon Systems Acquisition
29 Oct. 1969	DODD 7045.7	Planning, Programming, and Budgeting Systems
30 Oct. 1969	DODD 7200.4	Full Funding for DOD Procurement Programs
18 Nov. 1969	DODD 5010.8	DOD Value Engineering Program Guidance
19 Dec. 1969	DODI 7000.3	Selected Acquisition Report (SAR)
7 Jan. 1970	SECDEF Memo	DX Program Industrial Priority
28 May 1970	DEPSECDEF Memo	Policy Guidance on Major Weapon Systems Acquisitions
12 Jun. 1970	DODI 7000.3	Selected Acquisition Report (SAR)
23 Jun. 1970	DODD 5100.50	Protection and Enhancement of Environmental Quality
1 Oct. 1970	DODD 4100.35	Development of Integrated Logistic Support for Systems and Equipment

TABLE F.2-1. DOD GUIDANCE CHRONOLOGY (continued)

DATE	ITEM NUMBER	TITLE
21 Jan. 1971	DODD 4105.55	Selection and Acquisition of Automatic Data Processing Equipment (ADPE)
2 Jun. 1971	DODD 5000.19	Policies for the Management and Control of DOD Information Requirements
13 Jul. 1971	DODD 5000.1	Acquisition of Major Defense Systems
13 Sep. 1971	DODI 7000.3	Selected Acquisition Report (SAR)
16 Nov. 1971	DODI 4400.1	Priorities and Allocations -- Delegation of DO and DX Priorities and Allocations Authorities, Rescheduling of Deliveries, and Continuance of Related Manuals
3 Dec. 1971	DODD 4275.5	Industrial Facilities Expansion and Replacement
- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -
25 Jan. 1972	SECDEF Memo	Cost Estimating for Major Defense Systems
2 Feb. 1972	DODD 5010.8	DOD Value Engineering Program
9 Feb. 1972	DODD 4155.1	Quality Assurance
25 Apr. 1972	DODI 7000.2	Performance Measurement for Selected Acquisitions
19 May 1972	DODD 4105.55	Selection and Acquisition of Automatic Data Processing Resources
14 Jul. 1972	DODI 4200.15	Manufacturing Technology Program
28 Jul. 1972	DODD 5010.16	Defense Management Education and Training Program
18 Oct. 1972	DODI 7041.3	Economic Analysis and Program Evaluation for Resource Management
- - - - - - - - - -	- - - - - - - - - -	- - - - - - - - - -
3 Jan. 1973	DODI 7000.10	Contract Cost Performance, Funds Status and Cost/Schedule Status Reports
19 Jan. 1973	DODD 5000.3	Test and Evaluation

TABLE F.2-1. DOD GUIDANCE CHRONOLOGY (continued)

DATE	ITEM NUMBER	TITLE
20 Feb. 1973	DODD 4140.40	Basic Objectives and Policies on Provisioning of End Items of Material
24 May 1973	DODD 5100.50	Protection and Enhancement of Environmental Quality
6 Jun. 1973	DODD 4120.3	Department of Defense Standardization Program
13 Jun. 1973	DODD 5000.4	OSD Cost Analysis Improvement Group
5 Sep. 1973	DODI 7000.11	Contractor Cost Data Reporting (CCDR)
- - - - - - - -		
23 Jan. 1974	DODD 2000.9	International Coproduction Projects and Agreements Between the U.S. and Other Countries or International Organizations
6 Aug. 1974	DODI 7000.10	Contract Cost Performance, Funds Status and Cost/Schedule Status Reports
17 Oct. 1974	DODI 5000.22	Guide to Estimating Cost of Information Requirements
- - - - - - - -		
7 Jan. 1975	DODI 4151.9	Technical Manual Management
21 Jan. 1975	DODD 5000.26	Defense Systems Acquisition Review Council (DSARC)
25 Jan. 1975	DODI 5000.2	Decision Coordinating Paper (DCP) and the Defense Systems Acquisition Review Council (DSARC)
26 Mar. 1975	DODI 4151.7	Uniform Technical Documentation for Use in Provisioning of End Items of Material
23 May 1975	DODD 5000.28	Design-to-Cost
23 Sep. 1975	DODI 7000.3	Selected Acquisition Report (SAR)
22 Dec. 1975	DODD 5000.1	Acquisition of Major Defense Systems

TABLE F.2-1. DOD GUIDANCE CHRONOLOGY (continued)

DATE	ITEM NUMBER	TITLE
6 Jan. 1976	DODD 4105.62	Selection of Contractual Sources for Major Defense Systems
10 Feb. 1976	DODI S-4410.3	Policies and Procedures for the DOD Master Urgency List
12 Mar. 1976	DODD 5000.19	Policies for the Management and Control of Information Requirements
26 Apr. 1976	DODD 5000.29	Management of Computer Resources in Major Defense Systems
12 May 1976	DODD 5010.8	DOD Value Engineering Program
3 Nov. 1976	DODD 5530.3	International Agreements
28 Dec. 1976	DODD 4120.20	Development and Use of Non-Government Specifications and Standards
18 Jan. 1977	DODD 5000.1	Major System Acquisitions
18 Jan. 1977	DODD 5000.2	Major System Acquisition Process
10 Mar. 1977	DODI 5000.32	DOD Acquisition Management Systems and Data Requirements Control Program
11 Mar. 1977	DODD 2010.6	Standardization and Interoperability of Weapon Systems and Equipment Within the North Atlantic Treaty Organization (NATO)
9 Apr. 1977	DODD 4120.21	Specifications and Standards Application
10 Jun. 1977	DODI 7000.2	Performance Measurement for Selected Acquisitions
31 Oct. 1977	DODD 5000.34	Defense Production Management
8 Mar. 1978	DODD 5000.35	Defense Acquisition Regulatory System
4 Apr. 1978	DODI 4410.3	Policies and Procedures for the DOD Master Urgency List

TABLE F.2-1. DOD GUIDANCE CHRONOLOGY (continued)

DATE	ITEM NUMBER	TITLE
11 Apr. 1978	DODD 5000.3	Test and Evaluation
16 May 1978	DODI 4170.9	Defense Contractor Energy Shortages and Conservation
6 Jun. 1978	DODI 4155.19	NATO Quality Assurance
13 Jul. 1978	DODD 4275.5	Acquisition and Management of Industrial Resources
10 Aug. 1978	DODD 4155.1	Quality Program
6 Dec. 1978	DODI 5000.36	System Safety Engineering and Management
- - - - - - -		
24 Jan. 1979	DODI 5000.38	Production Readiness Reviews
10 Feb. 1979	DODD 4120.3	Defense Standardization and Specification Program
4 Apr. 1979	DODI 7000.3	Selected Acquisition Reports (SAR)
1 May 1979	DODD 5010.19	Configuration Management
3 Dec. 1979	DODI 7000.10	Contract Cost Performance, Funds Status and Cost/Schedule Status Reports
6 Dec. 1979	DODD 5530.3	International Agreements
26 Dec. 1979	DODD 5000.3	Test and Evaluation
- - - - - - -		
17 Jan. 1980	DODD 5000.39	Acquisition and Management of Integrated Logistic Support for Systems and Equipment
5 Mar. 1980	DODD 2010.6	Standardization and Interoperability of Weapon Systems and Equipment Within the North Atlantic Treaty Organization (NATO)
19 Mar. 1980	DODD 5000.1	Major System Acquisitions
19 Mar. 1980	DODI 5000.2	Major System Acquisition Procedures
6 Oct. 1980	DODD 4275.5	Acquisition and Management of Industrial Resources

TABLE F.2-1. DOD GUIDANCE CHRONOLOGY (continued)

DATE	ITEM NUMBER	TITLE
30 Oct. 1980	DODD 5000.4	OSD Cost Analysis Improvement Group
3 Nov. 1980	DODD 4120.21	Application of Specifications, Standards and Documents in the Acquisition Process

TABLE F.2-2. DOD GUIDANCE, NUMERIC LISTING

ITEM NUMBER	TITLE	DATE
SECDEF Memo	DX Program Industrial Priority Ratings	7 Jan. 1970
SECDEF Memo	Cost Estimating for Major Defense Systems	25 Jan. 1972
DEPSECDEF Memo	Establishment of a Defense Systems Acquisition Review Council	30 May 1969
DEPSECDEF Memo	Improvement in Weapon Systems Acquisition	31 Jul. 1969
DEPSECDEF Memo	Policy Guidance on Major Weapon Systems Acquisition	28 May 1970
DODD 2000.9	International Coproduction Projects and Agreements Between the U.S. and Other Countries or International Organizations	26 Mar. 1968
DODD 2000.9	International Coproduction Projects and Agreements Between the U.S. and Other Countries or International Organizations	23 Jan. 1974
DODD 2010.6	Standardization and Interoperability of Weapon Systems and Equipment Within the North Atlantic Treaty Organization (NATO)	11 Mar. 1977
DODD 2010.6	Standardization and Interoperability of Weapon Systems and Equipment Within the North Atlantic Treaty Organization (NATO)	5 Mar. 1980
DODD 3200.9	Initiation of Engineering and Operational Systems Development	1 Jul. 1965
DODD 4100.35	Development of Integrated Logistic Support for Systems and Equipment	1 Oct. 1970

TABLE F.2-2. DOD GUIDANCE, NUMERIC LISTING (continued)

ITEM NUMBER	TITLE	DATE
DODD 4105.55	Selection and Acquisition of Automatic Data Processing Equipment (ADPE)	21 Jan. 1971
DODD 4105.55	Selection and Acquisition of Automatic Data Processing Resources	19 May 1972
DODD 4105.62	Proposal Evaluation and Source Selection	6 Apr. 1965
DODD 4105.62	Selection of Contractual Sources for Major Defense Systems	6 Jan. 1976
DODD 4120.3	Defense Standardization Program	23 Apr. 1965
DODD 4120.3	Department of Defense Standardization Program	6 Jun. 1973
DODD 4120.3	Defense Standardization and Specification Program	10 Feb. 1979
DODD 4120.20	Development and Use of Non-Government Specifications and Standards	28 Dec. 1976
DODD 4120.21	Specifications and Standards Application	9 Apr. 1977
DODD 4120.21	Application of Specifications, Standards and Documents in the Acquisition Process	3 Nov. 1980
DODI 4140.19	Phased Provisioning of Selected Items for Initial Support of Weapons Systems, Support Systems, and End Items of Equipment	1 May 1968
DODD 4140.40	Basic Objectives and Policies on Provisioning of End Items of Material	20 Feb. 1973

TABLE F.2-2. DOD GUIDANCE, NUMERIC LISTING (continued)

ITEM NUMBER	TITLE	DATE
DODI 4151.7	Management of Technical Data	5 Dec. 1968
DODI 4151.7	Uniform Technical Documentation for Use in Provisioning of End Items of Material	26 Mar. 1975
DODI 4151.9	Technical Manual Management	24 Jan. 1969
DODI 4151.9	Technical Manual Management	7 Jan. 1975
DODD 4155.1	Quality Assurance	9 Feb. 1972
DODD 4155.1	Quality Program	10 Aug. 1978
DODI 4155.19	NATO Quality Assurance	6 Jun. 1978
DODI 4170.9	Defense Contractor Energy Shortages and Conservation	16 May 1978
DODI 4200.15	Manufacturing Technology Program	30 Jan. 1969
DODI 4200.15	Manufacturing Technology Program	14 Jul. 1972
DODD 4275.5	Industrial Facilities Expansion and Replacement	3 Dec. 1971
DODD 4275.5	Acquisition and Management of Industrial Resources	13 Jul. 1978
DODD 4275.5	Acquisition and Management of Industrial Resources	6 Oct. 1980

TABLE F.2-2. DOD GUIDANCE, NUMERIC LISTING (continued)

ITEM NUMBER	TITLE	DATE
DODI 4400.1	Priorities and Allocations -- Delegation of DO and DX Priorities and Allocations Authorities, Rescheduling of Deliveries and Continuance of Related Manuals	16 Nov. 1971
- - - - -	- - - - -	- - - - -
DODI S-4410.3	Policies and Procedures for the DOD Master Urgency List	10 Feb. 1976
DODI 4410.3	Policies and Procedures for the DOD Master Urgency List	4 Apr. 1978
- - - - -	- - - - -	- - - - -
DODD 5000.1	Acquisition of Major Defense Systems	13 Jul. 1971
DODD 5000.1	Acquisition of Major Defense Systems	22 Dec. 1975
DODD 5000.1	Major System Acquisitions (Implements A-109)	18 Jan. 1977
DODD 5000.1	Major System Acquisitions	19 Mar. 1980
- - - - -	- - - - -	- - - - -
DODI 5000.2	Decision Coordinating Paper (DCP) and the Defense Systems Acquisition Review Council (DSARC)	25 Jan. 1975
DODD 5000.2	Major System Acquisition Process	18 Jan. 1977
DODI 5000.2	Major System Acquisition Procedures	19 Mar. 1980
- - - - -	- - - - -	- - - - -
DODD 5000.3	Test and Evaluation	19 Jan. 1973
DODD 5000.3	Test and Evaluation	11 Apr. 1978
DODD 5000.3	Test and Evaluation	26 Dec. 1979
- - - - -	- - - - -	- - - - -
DODD 5000.4	OSD Cost Analysis Improvement Group	13 Jun. 1973
DODD 5000.4	OSD Cost Analysis Improvement Group (Update)	30 Oct. 1980

TABLE F.2-2. DOD GUIDANCE, NUMERIC LISTING (continued)

ITEM NUMBER	TITLE	DATE
DODD 5000.19	Policies for the Management and Control of DOD Information Requirements	2 Jun. 1971
DODD 5000.19	Policies for the Management and Control of Information Requirements	12 Mar. 1976
DODI 5000.22	Guide to Estimating Cost of Information Requirements	17 Oct. 1974
DODD 5000.26	Defense Systems Acquisition Review Council (DSARC)	21 Jan. 1975
DODD 5000.28	Design-to-Cost	23 May 1975
DODD 5000.29	Management of Computer Resources in Major Defense Systems	26 Apr. 1976
DODI 5000.32	DOD Acquisition Management Systems and Data Requirements Control Program	10 Mar. 1977
DODD 5000.34	Defense Production Management	31 Oct. 1977
DODD 5000.35	Defense Acquisition Regulatory System	8 Mar. 1978
DODI 5000.36	System Safety Engineering and Management	6 Dec. 1978
DODI 5000.38	Production Readiness Reviews	24 Jan. 1979

TABLE F.2-2. *DOD GUIDANCE, NUMERIC LISTING* (continued)

ITEM NUMBER	TITLE	DATE
DODD 5000.39	Acquisition and Management of Integrated Logistic Support for Systems and Equipment	17 Jan. 1980
DODD 5010.7	DOD Value Engineering Program	29 May 1969
DODD 5010.8	DOD Value Engineering Program Guidance	18 Nov. 1969
DODD 5010.8	DOD Value Engineering	2 Feb. 1972
DODD 5010.8	DOD Value Engineering Program	12 May 1976
DODI 5010.12	Management of Technical Data	5 Dec. 1968
DODD 5010.14	System/Project Management	4 May 1965
DODD 5010.16	Defense Management Education and Training Program	12 Sep. 1966
DODD 5010.16	Defense Management Education and Training Program	28 Jul. 1972
DODD 5010.19	Configuration Management	17 Jul. 1968
DODD 5010.19	Configuration Management	1 May 1979
DODD 5010.20	Work Breakdown Structures for Defense Materiel Items	31 Jul. 1968
DODI 5010.21	Configuration Management Implementation Guidance	6 Aug. 1968

TABLE F.2-2. DOD GUIDANCE, NUMERIC LISTING (continued)

ITEM NUMBER	TITLE	DATE
DODD 5100.50	Environmental Pollution Control	4 Jan. 1966
DODD 5100.50	Protection and Enhancement of Environmental Quality	23 Jun. 1970
DODD 5100.50	Protection and Enhancement of Environmental Quality	24 May 1973
- - - - - -	- -	- - - - - -
DODD 5530.3	International Agreements	3 Nov. 1976
DODD 5530.3	International Agreements	6 Dec. 1979
- - - - - -	- -	- - - - - -
DODD 7000.1	Resource Management Systems of the Department of Defense	22 Aug. 1966
- - - - - -	- -	- - - - - -
DODD 7000.2	Performance Measurement for Selected Acquisitions	22 Dec. 1967
DODI 7000.2	Performance Measurement for Selected Acquisitions	25 Apr. 1972
DODI 7000.2	Performance Measurement for Selected Acquisitions	10 Jun. 1977
- - - - - -	- -	- - - - - -
DODI 7000.3	Selected Acquisition Report (SAR)	28 Feb. 1968
DODI 7000.3	Selected Acquisition Report (SAR)	19 Dec. 1969
DODI 7000.3	Selected Acquisition Report (SAR)	12 Jun. 1970
DODI 7000.3	Selected Acquisition Report (SAR)	13 Sep. 1971
DODI 7000.3	Selected Acquisition Report (SAR)	23 Sep. 1975
DODI 7000.3	Selected Acquisition Reports (SAR)	4 Apr. 1979

TABLE F.2-2. DOD GUIDANCE, NUMERIC LISTING (continued)

ITEM NUMBER	TITLE	DATE
DODI 7000.10	Contract Cost Performance, Funds Status and Cost/Schedule Status Reports	3 Jan. 1973
DODI 7000.10	Contract Cost Performance, Funds Status and Cost/Schedule Status Reports	6 Aug. 1974
DODI 7000.10	Contract Cost Performance, Funds Status and Cost/Schedule Status Reports	3 Dec. 1979
DODI 7000.11	Contractor Cost Data Reporting (CCDR)	5 Sep. 1973
DODI 7041.3	Economic Analysis of Proposed Department of Defense Investments	19 Dec. 1966
DODI 7041.3	Economic Analysis of Proposed Department of Defense Investments	26 Feb. 1969
DODI 7041.3	Economic Analysis and Program Evaluation for Resource Management	18 Oct. 1972
DODI 7045.7	Review and Approval of Changes to the Five Year Defense Program	22 Dec. 1967
DODD 7045.7	Planning, Programming and Budgeting Systems	29 Oct. 1969
DODD 7200.4	Full Funding for DOD Procurement Programs	30 Oct. 1969

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SECTION 3

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2. "Statement by Dale Church, Deputy Under Secretary of Defense for Acquisition Policy, before the House Armed Services Committee," Federal Contracts Report, 29 September 1980, pp. H1-H2.

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6. U.S. Minerals Vulnerability: National Policy Implications, Subcommittee on Mines and Mining of the Committee on Interior and Insular Affairs, U.S. House of Representatives, 96th Congress 2nd Session, November 1980.

7. 1981 U.S. Industrial Outlook, U.S. Department of Commerce, January 1981.

8. Annual Report on the Status of the Shipbuilding and Ship Repair Industry of the U.S. - 1979, Coordinator of Shipbuilding, Conversion and Repair, Department of Defense, 90M/Law Ser 54, 27 March 1980.

9. Larrabee, Judith H., et al., Analysis of Critical Parts and Materials, The Analytic Sciences Corporation, TR-3370, December 1980.

10. Miller, Barry, "Lack of Components Making Impact," Aviation Week and Space Technology, 1 April 1974, pp. 56-60.

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13. "Deputy Defense Secretary Carlucci's Decisions on Eight Issues Identified in the Defense Systems Acquisition Review," Federal Contracts Report, 11 May 1981, pp. E1-E5.

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3.3 Real GNP - Based on data from the Bureau of Economic Analysis, Department of Commerce.

3.4 Productivity - Based on data from the Bureau of Labor Statistics, Department of Labor.

FIGURE

3.5 Prime Rate - Based on data from the Board of Governors, Federal Reserve System.

3.6 Change in Business Inventories - Based on data from the Bureau of Economic Analysis, Department of Commerce.

3.7 Real Nonresidential Investment - Based on data from the Bureau of Economic Analysis, Department of Commerce.

3.8 Percent Unemployment - Based on data from the Bureau of Labor Statistics, Department of Labor.

3.9 Capacity Utilization - Based on data from the Wharton Index of Capacity, Wharton School of Finance.

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